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Pipe-Line Transmission of Crude Oil

CALIFORNIA'S OIL TRANSPORTATION SYSTEMS; THEIR DEVELOPMENT; PROBLEMS MET AND THEIR SOLUTIONS; PUMPING DIFFICULTIES; FLOW MEASUREMENT; EXTENT OF OIL MIXING. BY CHARLES W. GEIGER

DEVELOPMENT OF THE OIL industry in California during the past 20 yr. has not only resulted in its becoming the most important of California's basic industries, but has rivaled California's gold as a source of new wealth to the state and nation.

With large and small producers in all fields exerting their utmost efforts to bring production up to the maximum, the year 1918 has gone down into history as the most profitable in the history of petroleum production in the state, the value of the oil produced in the state during that year totaling $130,000,000, which was a net increase in value over the year of 1917 of $40,483,012.

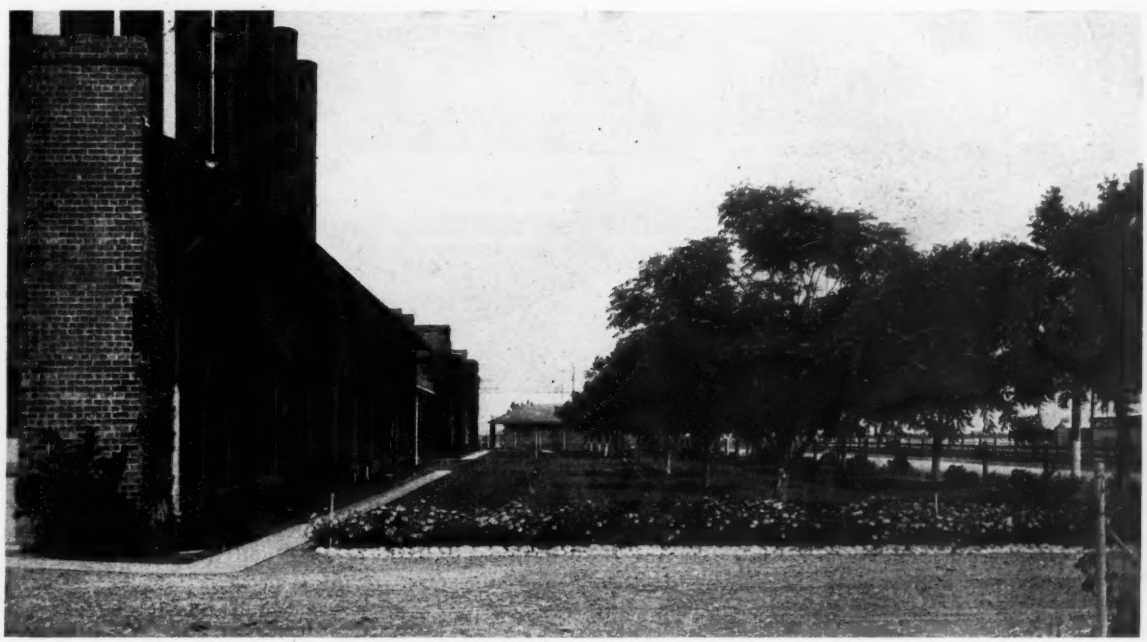


FIG. 1. EMERALD PUMPING STATION, PATTERSON, CALIF., SHOWING ATTRACTIVE SURROUNDINGS

The importance of petroleum and its products, however, is by no means measured by their money value. Their highest value is in their potential uses. As a factor in the development of industries and civilization of the Pacific Coast, South America, Australia and the Orient, no other products take precedence over petroleum. The oil is of particular importance to the commerce of the Pacific Coast. Thus, while California is a natural gateway for the commerce of the Orient, in its oil shipments to China and Australia, California figures not only as a transportation base, but as a main source of supply. The awakening of the Orient to the uses of oil and its products, cheap fuel oil, distillates, gasoline and lubricants, is a powerful influence in the opening of the industries of China and other over-sea countries. Alaska is an excellent illustration of how these products stimulate the development of new countries. In 1915, Alaska's exports were $60,000,000. Forty per cent of these were the products of fishing industries. About 50 per cent of the remainder was gold and copper. In all of them oil from California played its necessary part. Fuel oil was used in the operation of the mines and canneries, kerosene for lighting, heat-

ing and cooking; engine distillate and gasoline for fishing craft and shore engines. As an aid to distribution, one of the largest of California's oil companies maintains in Alaska a central base of supply and numerous smaller distributing stations.

The first known discovery of petroleum in California was made by sheep herders in Santa Barbara County (now Ventura County) while running their sheep in the mountain ranges for pasture; this was in 1860. It was in this county that the first attempt (in California) was made to produce oil for commercial purposes. Tunnels were run into the oil formations in Sulphur Mountain and small quantities of oil were floated out on the water that came with it. The mixture was run into flumes and thence into wooden tanks. When 25 or 50 barrels had been obtained, the water was settled out, leaving a heavy grade of natural lubricating oil. Most of this was hauled to Santa Barbara and shipped to San Francisco. Some was sold locally for use on harvesting and other machinery.

The first attempt at any large scale development in California was in 1864 and 1865, in Santa Barbara, Los Angeles and Humboldt Counties.

The principal operations were made by the Philadelphia & California Petroleum Co., operating in Ventura and Los Angeles Counties. All the drilling at this time was done on the anticlinal outcrops. A heavy oil was encountered which was soon passed through, the formation being on a very heavy dip. No material production was obtained, and the properties were sold out to satisfy the creditors.

No further attempt was made to drill wells on a commercial scale until late in 1875, when the California Star Oil Works Co. was formed by San Francisco men. This company commenced drilling in Pico Canyon, Los Angeles County, about 8 mi. west of the present town of Newhall. The effort was successful this time, a good grade of oil being encountered in paying quantities. The oil was 40 deg. gravity and found at shallow depths of from 60 to 400 ft.

A small refinery was constructed at Lyons Station, about 9 mi. from the wells. It consisted of two stills with a capacity of 75 bbl. per day, which was later brought up to about 200 bbl. per day. A second refinery was built at Ventura in the fall of 1876. Two years later the production of the Pico wells increased to about 300 bbl. per day and a new refinery was constructed at Newhall. The old refineries at Lyons Station and Ventura were dismantled and abandoned on the completion of the Newhall plant.

The expense of producing and refining crude oil up to this time had exceeded the returns, and drilling was suspended until 1879. In this year the Pacific Coast Oil Co. was formed, which started operations on a large scale. New wells were put down which gave an ultimate production of about 600 bbl. per day. A refinery with a refining capacity of 600 bbl. crude oil per day was built at Alameda Point, Alameda. A pipe line was laid from the wells to Newhall and from that point the oil was transported to the refinery in tank cars.

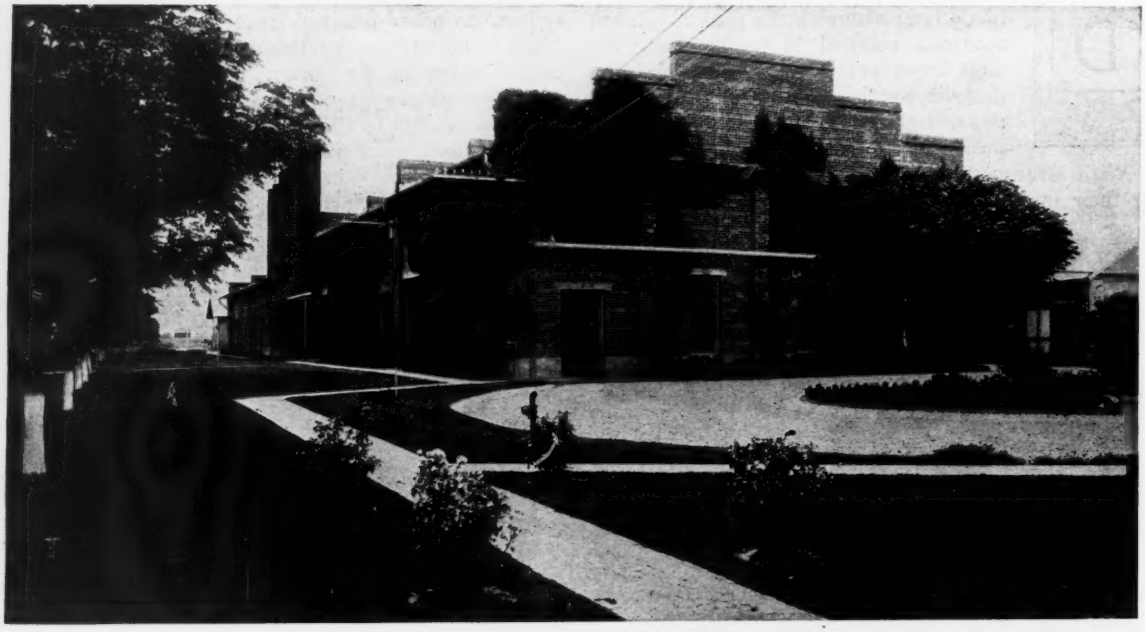


FIG. 2. ANOTHER VIEW OF EMERALD PUMPING STATION

This was the first use in California of the bulk method of handling oil—that is, the pipe-line and tank car method which has been such an important factor in the development of the oil business and in lowering the price of all petroleum products.

In the early part of 1895 the Pacific Coast Oil Co. completed a pipe line from Newhall to Ventura on the Pacific Ocean, and thereafter transported its oil from that section of the country to the Alameda Point refinery by tank steamer.

Refining Process Developed

Up to this time, 1895, it had been impossible commercially to refine California crudes so they could be

satisfactorily used for illuminating purposes. After the construction of the Alameda Refinery many attempts had been made from time to time to manufacture a refined oil which would prove safe and reliable, and compete successfully with the Eastern oils. These efforts were continuous from 1880 to about 1895, but all were unsuccessful and resulted in heavy losses to the company.

By the use of sulphuric anhydride (or fuming acid), the chemist of the Pacific Coast Oil Co. had successfully refined California crude in laboratory quantities so that it would burn by itself. But the anhydride had to be obtained from Germany at a cost of about $140 per ton, and this high cost made it impossible to refine oil commercially by this method.

About the year of 1890, the Pacific Coast Oil Co. entered into an arrangement to sell its refined product to the Standard Oil Co. By mixing it with Eastern refined oil, the Standard Oil Co. utilized this California product and put on the market a safe, reliable oil, with proper burning qualities.

This achievement in utilizing California crude oil by refining from it a safe, reliable illuminating oil, marked an important step in the development of the oil business in California. It not only supplied the people with a much-needed illumination, safe and inexpensive, but it furnished an outlet for one of the chief products of petroleum, without which the California industry could not have continued.

Up to 1900 only gasoline, refined oil, and the coarser grades of lubricating oils had been manufactured from California crudes; and the products were sold locally and at points to which there were easy transportation facilities.

Crude oil production in the fields was steadily increasing, and it became apparent that a much larger volume of business must be obtained, in order to cut down the cost of products and make possible successful competition with the Eastern refineries.

It was at this time that an extended system was devised for the wide distribution of petroleum products by the establishment of storage and distribution stations at all the principal points on the Pacific Coast.

With the extension of distributing facilities came a corresponding development in all other lines of the business—production, transportation and manufacturing. Vast reservoirs and other storage facilities were constructed in the Kern River oil fields to take care of the surplus oils which were being produced; a large modern refinery was erected at Richmond, on San Francisco Bay; and, to furnish quick, economical transportation to this refinery a pipe line over 300 mi. in length was laid from Richmond to the Kern River and Coalinga fields.

Pipe Line Transportation

THE ADVENT of the oil pipe line stands out as the first big economic step in the development of the oil industry in California. The transportation of California oil by pipe lines is done by several companies; the extent and location of the lines is shown by the accompanying map.

The principal pipe lines of California are owned by: Standard Oil Co.; Producers' Transportation Co.; Union Oil Co.; Associated Oil Co.; General Pipe Line Co. and Shell Oil Co.

The usual procedure in transporting oil through pipe lines is as follows: In each of the oil fields there is a gathering system of pipes from 2 to 6 in. in diameter, radiating from large storage tanks at a pump station on the main line and extending to the various producing properties. At each producing property there are storage tanks or reservoirs large enough to hold an accumulated production of several days or weeks. When a run of oil is to be made, a representative of the pipe line company, called a "gager," measures the depth of oil in the tank, and its temperature, and takes samples. He then unlocks and opens the gate valve, which admits the oil to steam pumps which force it through the gathering pipe to the main pump station. When the storage tank at the producing property is about empty, the valve is locked by the gager and the depth again measured. A run ticket is issued to the producer, showing the temperature, gravity, percentage of water and sediment, and the two measured depths.

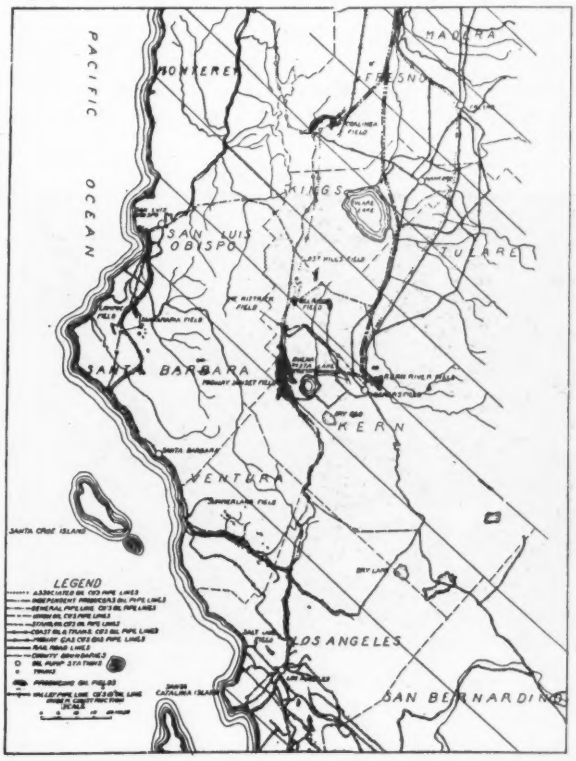


FIG. 3. PARTIAL MAP OF CALIFORNIA, SHOWING NETWORK OF OIL PIPE LINES

Transportation Difficulties

THE VARIOUS grades of California oil act very differently in a pipe line, and the subject is very intricate from an engineering standpoint. The low gravity oils are very thick or viscous at ordinary temperature, and to flow readily, require heating. The lighter oils flow more freely and some require no heating.

The usual diameter of a pipe on the main lines is 8 in. Pumping stations are placed from 12 to 15 mi.

apart. The oil enters the line under a pressure of from 600 to 800 lb. per sq. in. and is sometimes heated to a temperature of 150 or 160 deg. F. The loss of temperature and increase in viscosity depend upon the weather conditions, nature of the ground in which pipe is buried, and the kind of oil, so there is no definite distance at which stations can be placed. Upon reaching the next station the oil sometimes runs into storage tanks and sometimes goes directly to the suction pipes of the pumps. The temperature of heavy oil is usually not allowed to fall below 100 deg. while in the line.

The capacity of any line is subject to considerable variation, due to changes of weather and grade of oil. It is usually aimed to handle the heaviest oil during the warmest weather, when that is possible. Frequently light oil is stored along the line, to be mixed in if the heavy oil becomes too cold and sluggish.

When the change is made from light, cold oil to heavy, hot oil, the temperature must be changed slowly to prevent the sudden expansion from breaking the pipe. The same care is necessary in changing back to the cold oil.

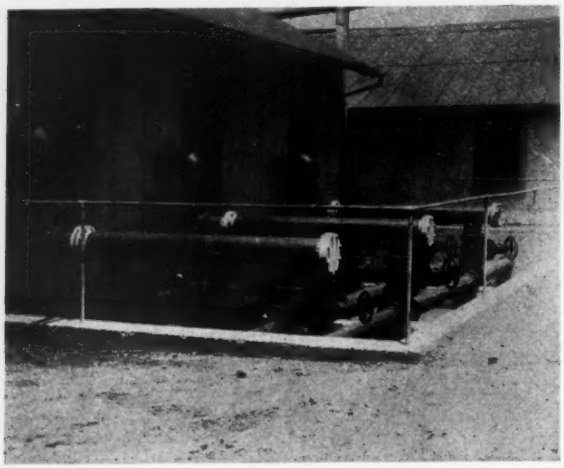


FIG. 4. ENTRANCE OF PIPE LINE TO REFINERY AT RICHMOND, CALIF.

The San Joaquin trunk pipe line of the Standard Oil Co. is the line in California best known to those outside the petroleum world. It connects the San Joaquin Valley fields with the San Pablo tank farm, which is 4.8 mi. from the Richmond Refinery on San Francisco Bay; 280.6 mi. in length, it is the company's longest line, and has the greatest carrying capacity.

The San Joaquin main trunk line begins at Bakersfield. Tributary to it are the branch lines which carry out the product of the Midway, Sunset, McKittrich, Kern River, Lost Hills-Belridge and Coalinga oil fields. Each of these branch lines in turn has its tributaries—the "gathering" lines extending from the field stations to the leases where the wells are located.

An oil line system has been likened to a river and its tributaries; the field for gathering lines represent the smaller streams and "feeders," the branch lines correspond to the larger streams, and the trunk line to the river itself.

Pumps and Pumping Stations

The leases have their field pumps, the field stations have their pumping plants, and a pump station is located about every fifteenth mile along the San Joaquin Valley trunk line from Bakersfield to San Pablo. At these trunk line stations, the pumping engines never cease. They operate night and day and, in order that repair work may be done without shutting down, every plant has an extra equipment of boilers and pumping apparatus. When the boilers are to be washed, others are fired to take their places. When a pump is to be packed or overhauled, there is always another ready to put its throb in the line.

The San Joaquin trunk line passes through some of the richest land in California and it passes through some very arid sections. The establishment of pump stations in the arid sections necessitated the development of water, and in many instances this was done in localities where hitherto the belief had been that water was unobtainable. At these desert stations there have been planted trees and shrubs and vines. The accompanying photographs show one of these pumping stations, which shows the unusual effect that has been produced. This is known as the Emerald pumping station. It is located in Stanislaus County and was declared the premium station of the North Division of the San Joaquin line. The award was made on the station's general neat appearance and because of the flourishing condition of the trees, lawns and flowers, due to the energy and interest of the employes of the station. This plant is equipped with a pump which weighs 300,000 lb., and can pump 50,000 bbl. of oil per day against a pressure of 600 lb. per sq. in.

Bungalows are maintained at each station for the employes. In the isolated sections through which the pipe line passes, travel generally follows the line, and thus new faces and incidents come to break the monotony of the routine work and the same eye-wearying and unchanging stretches of desert waste incidental to life at some of the pump stations. With occasional exceptions, the travelers are on company business—officials on an inspection tour, crews of mechanics, "pipeliners," and tank builders. They may come to a station on work requiring a month, or stop only for the night, their destination being further along the line. At every station now are one or more automobiles, owned by company employes, and with this means of travel, even those most remotely situated have ready access to one, perhaps several, of the larger valley towns or cities.

A frequent visitor at the pumping stations is the line walker. He drives a rig which enables him to carry a good equipment of tools. Owing to the character of the country some sections of the line are patrolled by men who travel on foot. Every foot of the pipe line is patrolled. On the lookout for leaks, the line walker travels back and forth over that section of the line for which he is responsible—usually about 30 mi. If patrolling on foot, instead of repair tools, he carries a pair of climbing irons and a telephone instrument. Wherever the company has an oil line, it also has its own telephone and telegraph wires, and communication between stations is but the matter of a moment. When a line walker discovers a certain unmistakable discoloration of the ground in the vicinity of the line, he investi-

gates to learn the nature of the leak, and if it is of such a character that he cannot repair it, he immediately climbs the handiest pole and reports to the nearest station. In a very brief space of time men with the necessary tools and material are on their way to do the repair work. The report of a leak in the line from one outside the company's employ is rewarded with a small bonus, and occasionally the word comes from a passing sheep herder or farmer.

All line pipe averages about 20 ft. in length and is painted with hot asphalt and wrapped in prepared asphalt covering before it is lowered into the ditch, when a new line is constructed. This is done to protect it as much as possible from alkali or other mineral destructive to steel. As a precautionary measure, every new pipe line is tested with water before it is entrusted with oil. If a water pressure, in excess of the working pressure which the line will have to withstand, shows no leaks or splits, the new line is adjudged as a fit carrier for oil and becomes a part of that service which connects the field with the refinery.

The San Joaquin pipe line was the pioneer line in California—that is, for conveying oil over long distances, and presented many problems. Heavy California crude oil is about as sticky as molasses. Most Eastern oil, on the other hand, flows almost as readily as water. Thus when, in 1902, Eastern petroleum engineers were asked to build the San Joaquin pipe line to carry this heavy oil from Bakersfield to San Francisco Bay, they were confronted with a problem about as strange to them as that of designing a line through which to pump molasses 300 mi. There was no guiding precedent, no past experience to point the way.

In the East, oil pipe-lines were begun on a very small scale. "Trunk lines" 300 mi. in length were not attempted until the way had been paved by a steady, successful growth from the smaller systems. Then the pipe lines expanded gradually from a meager beginning to the great systems of the present. But in California, the very first attempt to pipe San Joaquin Valley oil to tidewater involved a line nearly 300 mi. in length, extending from Bakersfield to Richmond. Through this long line it was necessary to pump an oil many times as sticky as anything that had ever been handled in the East.

The Standard Oil Co. of California was the first to attack this new and difficult problem. Early in 1903, the 8-in. San Joaquin line from Bakersfield to Richmond was completed. Pumping stations on this line were placed about 28 or 30 mi. apart, and heaters were installed in each station to melt the heavy oil so that it would flow easily through the pipe.

The pumps were started in March, 1903, at a time when the ground was cold and full of water. By the time the oil had flowed 15 or 20 mi. through a pipe buried in such ground it had lost all the heat put into it at the pumping station. The next pumping and heating station was still 10 or 15 mi. away. Pumping the cold, sticky oil through this last 10 or 15 mi. was about as difficult as pushing a plug of wax the same distance. The line, which could easily have handled over 20,000 bbl. of Eastern oil in a day, would deliver barely 1000 bbl. of the sticky Kern oil. This held true even when the pumps were forced to the highest pressures that they could develop or that the line could safely stand.

The warm summer weather brought some relief; but even on the hottest days, the oil in the last few miles of each 30-mi. stretch between stations would cool down well below 100 deg., and the flow still remained far below a satisfactory amount. In an effort to better it, water was mixed with the oil. This was in accordance with a practice that had been followed in handling small amounts of heavy oil produced in Ventura County. It did not, however, prove to be a successful or satisfactory method of improving conditions on the long Bakersfield line. By the time the cold weather of the next winter had set in, it became clear that in order to achieve success it would be necessary to redesign the line.

The solution proposed was to place intermediate stations between each of the 10 stations already built, thus cutting down to 14 or 15 mi. the length of line in which the oil could cool. To learn whether or not this proposal was successful, one has but to glance at a pipe-line map of California. The network of lines which now covers the San Joaquin Valley would never have been

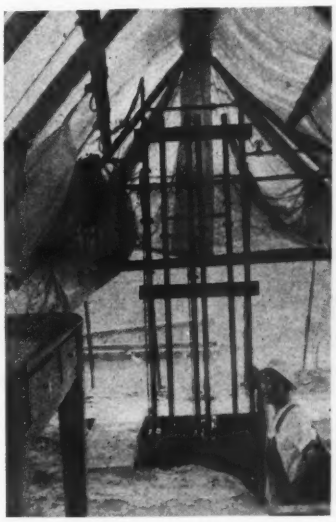


FIG. 5. THE BROMOFORM DIFFERENTIAL GAGE AS INSTALLED

built if there had existed any doubt as to their successful operation.

The problem of keeping the oil "melted" is just one of the many that have had to be solved during the progress from this pioneer line to the present extensive system. When the intermediate pump stations were completed, so that the oil could be given fresh heat and more pressure every 14 or 15 mi., the single 8-in. line had ample capacity to handle all the oil then available. Soon, however, the great gushers in the Midway field were brought it, and this single line at once became too small. To increase its capacity, "loops" were added between stations. A loop is simply a pipe laid parallel to the first line for part of its length and connected into it, so that throughout the length of the loop the stream of oil divides, part flowing through each line. With the help of these loops, the line carried for a time all the oil that was available; but as more and more big wells came in, it again became overloaded. The next logical step was to complete the loops, thus providing two parallel lines between stations. When the rapid

growth of the oil fields brought production up to a point which taxed these two 8-in. lines to the limit, and still more capacity was needed, it was decided to "loop" them again, this time with a 12-in. line. And so today the pioneer San Joaquin trunk line consists of two parallel 8-in. lines all the way from Bakersfield to San Pablo, with 12-in. loops spanning half of each of the 20 intervals between stations.

Every time it has been necessary to make one of these additions to the line, the designers have had to know how long or how large it must be to give the desired increase in capacity. The oil to be handled has included gravities ranging from the heavy molasses-like fluid first pumped, to oils as light as some of the Eastern products. Sometimes the demands of the refinery require that all lines pump light oil as fast as possible. At others, light and heavy oil must be delivered at the same time, and occasionally all the energy of the system must be devoted to moving heavy oil.

The questions of how big must the lines be to meet these varying demands successfully, and how much pressure will be required at each pump station to force the

FIG. 6. GENERAL VIEW OF EXPERIMENTAL PIPE LINE SHOWING TENT IN WHICH INSTRUMENT WAS LOCATED

maximum requirements of various oils through the different combinations of lines and loops have arisen whenever new lines or additions to old ones have been proposed. In order that these questions might be answered with the greatest possible accuracy, many experiments and much careful study have been devoted to the different factors influencing the flow of oil in pipes.

Oil Flow Tests

In the accompanying illustrations, Figs. 5 and 8, are shown equipment that was used in making practical flow tests. The daily pumping records of the various stations along the different pipe-lines afforded a basis upon which to start these investigations. These records showed the pressures needed to force oil of various gravities, having various initial temperatures, through certain lengths of pipe. It might seem at first sight that a careful analysis of such records would afford data upon which the flow of any given kind of oil could be predicted accurately. And, as a matter of fact, quite a little progress in the study of oil flow was made with the help of these records; but there were two obstacles which stood in the way of getting very comprehensive data from them.

In the first place, practical operating requirements made it difficult, if not impossible, to vary the rate of pumping over a very wide range. After a line had once been heated up, it was necessary to keep it hot by maintaining the flow at a fairly high rate. For this reason, the pumping records could provide data for only a few points, relatively close together, on "flow curve." They did not permit any investigation of flow at slow, nonturbulent speeds, or of the critical velocity. Furthermore, the lengths of line covered by the pumping records were so great—never less than about 15 mi.—that very wide variations in the temperature of the flowing oil always took place. This made it almost impossible to arrive at an accurate figure for the average viscosity of the oil; and as flow data must be on a viscosity basis in order that results for any one oil may be of value in predicting the flow of any other oil, or even of that same oil at a different average temperature, little progress toward the final analysis of flow problems was really made through the study of pumping records.

The next step was to take simultaneous observations of temperature and pressure at a number of places between pumping stations. Such tests—for these were really the first tests, as distinguished from the study of operating records described above—yielded results of great value and interest. In the comparatively short sections between observation points, the temperature drop was small enough to permit a fairly accurate estimate of the average viscosity, and the losses in pressure recorded for the various sections showed very clearly how the forces resisting flow increased as the temperature decreased.

These tests, therefore, marked a big advance over the study of station operating records. But there was still the difficulty that practical pumping requirements limited the available data to a comparatively narrow range of speeds. Then, too, the pressure gages used had to be large enough to withstand high line pressures, and for this reason they were not sufficiently sensitive to indicate accurately the small drop in pressure which takes place over a short length of pipe. The shortest practical spacing of gages proved to be about one mile. In a stretch this long, there were always considerable variations in the depth of the pipe below the ground surface, in its proximity to other pipes carrying hotter or colder oil, and in the heat-absorbing qualities of the soil. This left considerable doubt in regard to the true average temperature—and thus the average viscosity—of the oil.

Thus these tests between stations, while they afforded the very best data obtainable from the lines in actual operation, were still handicapped by a number of unavoidable inaccuracies. In an effort to get away from all these and to observe flow under accurately measurable and controllable conditions, it was decided to build some short pipe-lines exclusively for testing purposes. A site was selected where the oil could flow by gravity from a large storage tank at the top of a 100-ft. hill; for pressures can be much more accurately measured in a line carrying the steady flow due to gravity than in one where the flow is pulsating on account of the impulses of a reciprocating pump. Three parallel pipe-lines of different sizes were laid from this storage tank to a small measuring tank specially erected for the

purpose at the foot of the hill (and shown in Fig. 7). A steam pump was placed at this tank to pump the oil back to the storage tank each time the measuring tank became full. The storage tank was equipped with a steam coil, so that the oil could be brought to any desired practical temperature; and, in order that the flow through the test lines might be maintained at any desired rate, gate valves were placed at the lower end of each.

This equipment thus afforded opportunity for observing flow over a wide range of accurately controllable temperatures and velocities, up to limits far above practical operating conditions. There remained only the problem of measuring the drop in pressure due to any given flow. The arrangement of three parallel lines afforded an excellent means of doing this simply and accurately. For when no flow was taking place through any of the lines the pressure at the lower end of each was exactly the same—just equal to the "static head" between the point of observation and the level of the oil in the storage tank at the top of the hill. If, then, flow was permitted to take place through any one of the lines —the gate valves in the other two remaining closed—the difference between the pressure at the lower end of the line through which the oil was flowing and a corresponding point in either of the other lines would be an exact measure of the drop in pressure resulting from flow at the observed rate and temperature.

To observe this pressure difference, a "differential gage" was connected into the three lines just above the gate valves, as shown in Fig. 8. This type of gage is one of the most accurate devices known for measuring differences in pressure. It played such an important part in these and subsequent tests on oil flow that it will be well to outline at this point the principle on which it works.

As illustrated in Fig. 8, it is simply a glass U tube partially filled with mercury. The upper ends of the U tube are connected through suitable piping to the points between which a difference in pressure is to be measured. In order that the pressures may be transmitted to the tops of the mercury column, all the connections must be filled with some liquid. As far as accuracy is concerned, this liquid might be the oil in the pipes into which the gage is connected; but if this were the case, the inside walls of the U tube would be so clouded that it would be impossible to determine the height of the mercury column in either leg of the tube. For this reason, a column of water is placed above the mercury on both sides. The difference in elevation of the mercury in the two legs after a state of equilibrium has been reached will be an exact measure of the pressure diference between the points of connection.

The differential gage used for these gravity flow tests was so piped that by opening the proper valves it could be connected to any of the pipe-lines under test. When a gate is opened a certain amount of oil would flow through that line at a steady rate, which rate could be determined accurately by gaging the quantity delivered into the measuring tank in a given time. As described above, the pressure loss due to this flow could be measured by the difference in pressure indicated by the displacement of the mercury in the differential gage.

With this equipment, it was thus possible to measure with great accuracy the rate of flow and the pressure drop under any desired condition in each of the three test lines. The third important factor—the average temperature of the flowing oil—could be obtained with almost equal exactness; for the lines were short—only 450 ft.—and conditions were essentially uniform throughout their length; hence, by carefully observing the temperature of the oil where it was drawn from the storage tank, and again when it discharged into the measuring tank, a dependable indication of the average temperature—and thus the average viscosity—could be obtained.

Several months of painstaking work with these test lines yielded a complete set of curves indicating the flow of heavy oil in 2, 3, and 4-in. pipes at various temperatures. While this method of measuring the flow due to gravity proved very successful for investigating the smaller sizes of lines, it was not practical for the larger

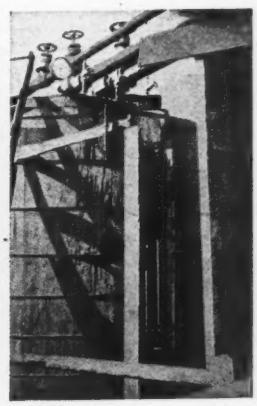


FIG. 7. THREE EXPERIMENTAL PARALLEL PIPE LINES OF DIFFERENT SIZES

FIG. 8. DIFFERENTIAL GAGE USED TO MEASURE PRESSURE DIFFERENCES IN PIPE LINES

sizes on account of the large quantities of oil which would have to be handled and the consequent great cost of the testing equipment which would be necessary; therefore, some scheme had to be devised for measuring the small differences in pressure which occur when oil flows at commercial velocities through a stretch of 8, 10 or 12-in. line that is short enough to insure uniform temperature conditions, i. e., about 300 or 400 ft.

After the successful use of the differential gage for the gravity tests, this was the first thing to suggest itself for taking observations in the tests of the larger trunk lines; but it was found that the pressure drops encountered in practicable lengths of line were so small that the total displacement of the mercury column was only an inch or two. An error of a few hundredths of an inch in reading a column of this height would be of very serious relative magnitude, and so it became necessary to use some other liquid. After considerable experimenting, it was found that bromoform or carbon tetrachloride would be suitable.

(Continued on Page 1072)

Invoicing Your Ability

UP in the old barn loft, now used as a storing place for old things for which nobody seems to care, but allowed for some more or less sentimental reason to remain on the premises, I found a priceless gem. Not the kind that you take to the jeweler and barter for so much filthy lucre, which, like the seven loaves and three fishes, can be given away and divided with others ad infinitum and each division makes the giver the richer. Now I am going to give it to you and hope that you make the most of it.

In that barn, now used as a garage, I played, as a boy, everything imaginable, from yeggman to basso profundo in grand opera. This gem lay there all that time. It had belonged to my father. Where he got it I do not know, neither do I believe he knew its value, for he never spoke of it nor mentioned it in his will. But it had a tangible value to me, still has, and will have to you if you will but polish it up and give it the setting to suit the style of your profession.

"I STARTED THE BIG CORLISS TODAY FOR THE FIRST TIME," I READ ON; "JACK SAID I DID A GOOD JOB OF IT"

Here it is—the germ of an ideal hidden in an old diary written while Father was learning his trade. He wrote it and forgot what he had written. I read it as a boy and forgot. Visiting my youthful haunts a few years ago I read it again as a man weary of the search for the gold bag at the end of the rainbow. This time its value to me was made known. I conceived an idea; I polished it and use it as evidence of my success.

"I started the big Corliss today for the first time," I read on; "Jack said I did a good job of it. The belt lacing tore out on the main drive today and we had to shut down; but we made record time in getting her back; only 20 min." Page after page was written of Father's everyday work, his wishes, hopes, ambitions, accomplishments, studies, finances, health—everything. Useless, absolutely time wasted and his note books tossed away in the old barn loft to be forgotten until I conceived the idea of invoicing my own ability, not merely keeping a day book but making a yearly statement of my personal achievements.

What's the idea? Merely to aid me in reaching my ideals by pointing to successes and failures, showing what I can do and what I cannot do; what I have done with my time and how it can be used to better advantage; the type of men with whom I can do best work and the type that interferes—all these and many more things I have learned by a carefully kept diary and a yearly invoice.

Like planning a power plant record, one must plan his notes for his diary. Fortunate is the man who knows himself thoroughly and can produce evidence that he is the man he says he is. Plan your diary and invoice to show this. Here are some of the things I regularly record at each invoicing period of the year:

What new accomplishment have I attained during the past year?

What speed have I gained in my regular work?

What original ideas have I worked out successfully? What failed?

What suggestions of others have I worked out successfully?

What recommendations have I made to others that were worked out successfully and what failed?

What recommendations have I made that were rejected, and why?

Study yourself as you would a machine that is acting crazy, because we all have some foolish notions. That foolish notion doesn't get across, even with our most devoted friends. In many cases it is worth big money to know why. It may be an impractical idea; it may not have been presented in the right way or to the right people. The idea may have been half-baked or, as lawyers put it, "the proper foundation not laid."

Design your invoice to put you on a firm foundation, to know exactly what your capacity has been and to encourage you along definite, desired lines where success is worth striving for. Determine whether you are going forward, standing still, or in reverse gear.

A study of your success with ideas and recommendations alone is worth many times the trouble taken to make that study. It will show conclusively whether or not you have a brain fertile with original, practical ideas and determine your ability to work them out. It will show your success in selecting the proper men to carry out your plans or your success in working others' ideas. It will, in other words, mark your success as an executive or a detail man. The sooner one finds himself, the sooner will he be able to reach success.

The idea may be raw to you, probably is; but if you will work with it a while, its practical use will be revealed and you will be the beneficiary.

THE WEEKLY launching report of the Emergency Fleet Corporation to the United States Shipping Board, shows that during the week ending Oct. 18, vessels were going overboard at a rate exceeding three a day. Fifteen steel steamships, built under contract to the Fleet Corporation, one requisitioned steel steamship, five wood vessels (including barges and tugs) and one concrete steamship were launched during the week, a total of 22 vessels, aggregating 117,700 deadweight tons (78,467 gross tons).

WITH the close of the active building season the United States faces a housing shortage equal to the needs of 4,000,000 people.

Fire Pumps

VARIOUS TYPES, THEIR CONSTRUCTION AND METHODS OF DRIVING. BY CHARLES L. HUBBARD

ALTHOUGH occupying an important position in the power plant, the fire pump is apt to be overlooked to some extent, because it is seldom brought into operation; while the boilers, engines, and the other pumping machinery are in constant use, and therefore demand careful attention. The fire pump, however, is likely to be called upon at any moment day or night, although it may be years between such calls, and it must be kept in perfect condition for instant service. The

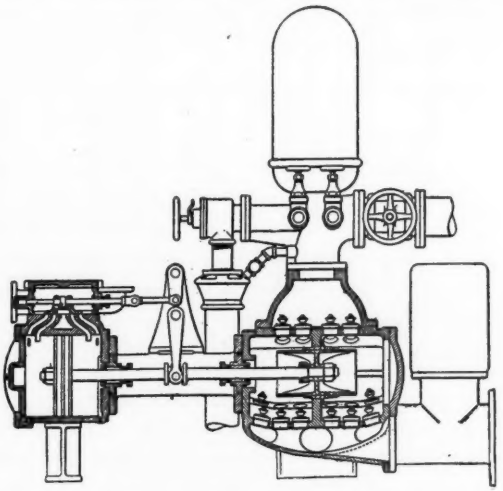


FIG. 1. STANDARD DUPLEX TYPE OF FIRE PUMP

engineer and night fireman must be familiar with its operation so as to know where to look for defects, often under the excitement of a sudden call for service.

Pumps for fire service are designed and installed under the direction of the fire underwriters, so that this part of the work does not come within the field of the operating engineer.

He should, however, be familiar with their construction in order to understand clearly the various adjust-

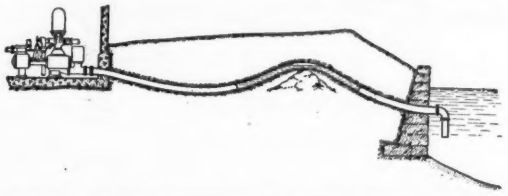


FIG. 2. FAULTY METHOD OF LAYING SUCTION PIPE

ments, and their operation under the strenuous conditions of actual service.

The three different types of pumps used for fire protection are the direct-acting steam pump, the rotary, and the centrifugal pump, of which the first is probably the most widely used.

UNDERWRITER STEAM FIRE PUMP

THIS pump is regularly made in four sizes, having capacities of 500, 750, 1000, and 1500 gal. of water per minute at a pressure of 100 lb. per square inch. It is of the standard duplex type, one side being shown in section in Fig. 1. The principal points of difference as compared with the ordinary commercial pump, are in the increased size of the water passages and air chamber; in "rust proofing" the water piston, piston and valve rods, and stuffing boxes by making them of brass or bronze instead of steel; and by adding various attachments such as vacuum chamber, pressure gages, relief valve, hose valves, sight-feed lubricator, etc.

The standard allowance for a $1\frac{1}{8}$-in. smooth nozzle fire stream is 250 gal. per min. at 100 lb. pressure; and from 15 to 20 automatic sprinklers may be taken as

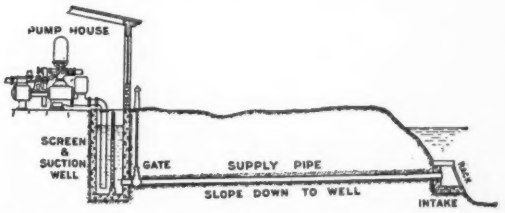


FIG. 3. PROPER ARRANGEMENT FOR LONG SUCTION PIPES

discharging about the same quantity under ordinary conditions.

It is important that the supply or suction pipe be as short as possible and that the lift be limited to 15 ft. or less except in special cases. Care should be taken in laying the suction pipe to have a constantly ascending grade in order to avoid "summits" for the accumulation of air as illustrated in Fig. 2. This has the effect of reducing the area of the pipe and cutting down the water supply.

Extremely long suction pipes should be avoided, and when the distance exceeds 100 ft. it is best to supply the

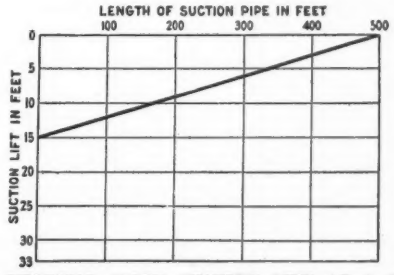


FIG. 4. SHOWING ADDED SUCTION LIFT AS A RESULT OF USING A LONG SUCTION PIPE

arrangement shown in Fig. 3, which consists of a suction well, located near the pump, supplied by gravity flow through a pipe grading downward and toward it. There should always be a certain relation between the length of the suction pipe and the vertical lift, as the total lift is made up of the height through which the water must be raised plus the frictional resistance of the pipe. The curve shown in Fig. 4 gives the relation for different lengths of pipe.

A standard sprinkler system requires a primary water

supply either from an elevated tank of large size or from city mains of ample size with abundant pressure.

It is imperative that the system act instantly upon the opening of a sprinkler head and a sufficient primary supply should be available to last until the pump can be put in operation. Under the conditions stated this is best done by hand after the fire starts, as this eliminates all complicated automatic apparatus which is likely to get out of order. In order to keep the pump primed at all times, in cases where the water must be lifted by suction, an elevated tank is provided, having a capacity equal to one-half the maximum volume of water discharged by the pump per minute, or water is taken automatically from the city mains. Priming valves are provided for use when starting up the pump. The most approved type is that in which the inlet of water and outlet of air is accomplished simultaneously by the same valve. Four of these valves are provided, and they should be closed after the pump is primed and in working order.

Where the primary supply is limited, automatic attachments are provided for keeping the pump primed and starting it as soon as the pressure drops in the supply system, due to the opening of a sprinkler head. This necessitates the use of a small auxiliary pump for keeping the main pump primed, and governers for operating both pumps automatically.

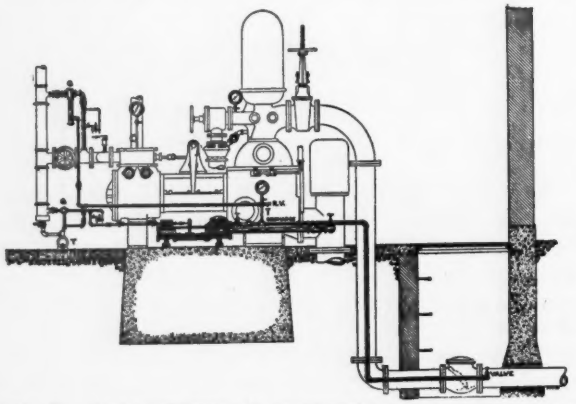


FIG. 5. ARRANGEMENT OF PRIMING PUMP WHEN WATER SUPPLY IS UNDER A HEAD

When the water is supplied under a head the plan shown in Fig. 5 may be used, the auxiliary priming pump taking its supply from the suction pipe of the main pump near the cylinders and discharging into the main delivery pipe beyond the check valve. The automatic governors, G and G¹, controlling the steam valves on the pump, are connected with the pressure in the sprinkler system through a pipe leading from the discharge from the auxiliary pump. T is a steam trap for taking care of the condensation, and RV a relief-valve to prevent the small pump from putting a dangerously high pressure on the system. Cut-out valves are provided on all automatic and auxiliary apparatus so that the main pump may be operated by hand in the usual manner, if desired.

A piping plan for pumps with suction pipes and lift of 10 ft. or less is shown in Fig. 6. Here the small pump takes its supply from the main suction as before, but discharges into the pulsation chambers of the large pump through the priming connections. There is also a valved connection with a priming tank for use in case of accident to the small pump. The pump governors G G¹ and trap T are the same as in Fig. 5. No relief valve is required, as the small pump operates against the relief valve of the main pump. This arrangement is also suitable where the water is supplied to the pump under a head. For long suction pipes with a lift over 10 ft., requiring a foot valve, the plan shown in Fig. 7 is used. In this case the suction supply for the small pump is drawn from its source independently of the large pump, and the discharge is into the suction pipe of the main pump as indicated in the drawing. It is important in case of a pump operated by an automatic governor to keep it primed, as there is almost sure to be some damage done when steam is first turned on if there is not sufficient water in the pump and suction to prevent racing.

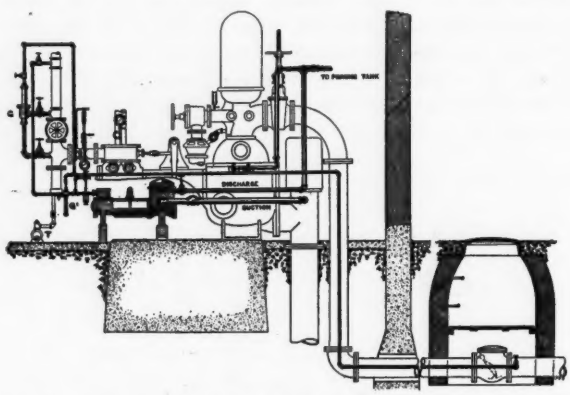


FIG. 6. ARRANGEMENT OF PRIMING PUMP WHEN SUCTION LIFT IS 10 FT. OR LESS

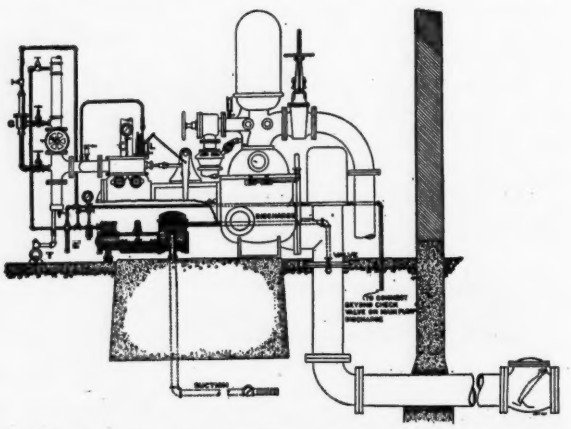


FIG. 7. PRIMING ARRANGEMENT FOR PUMPS WITH LONG SUCTION PIPE AND A SUCTION LIFT OF OVER 10 FT.

A short suction pipe, if well supported, is best made up of flanged pipe with rubber gaskets; but if of considerable length and in yielding soil, bell-and-spigot pipe should be made up with leaded joints. The average situation does not require a foot-valve, this being limited to long runs and high lifts. No pumps for other than fire service should be connected with the suction of the main fire pump as it is likely to interfere with its proper working in time of need.

An indicating gate valve should be placed in the

discharge pipe close to the pump, as by this means it will still be possible to run hose lines from the pump, in case of accident to the discharge line beyond the valve.

A check valve should also be placed in this line, preferably outside the pump house in a well protected but accessible pit.

The steam supply for a fire pump should always be an independent line from the boilers, run in such a way as to protect it from injury as much as possible in case of fire. The other steam pipes leading from the boilers should be provided with valves located in the boiler room so that they may be closed in case of emergency, leaving the whole steam supply available for the fire pump.

The exhaust pipe should run direct to the atmosphere without valves, and should never connect with a condenser, heater, or other system of exhaust piping. Every fire pump is provided with a relief valve to prevent the pressure from rising above a fixed point and to take care

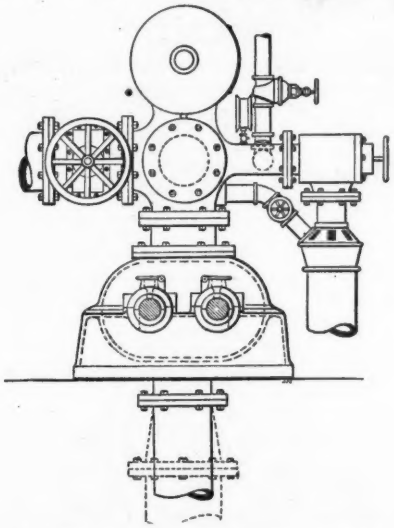


FIG. 8. END ELEVATION OF ROTARY FIRE PUMP

of the excess water above that used by the sprinklers in operation. The discharge passes into a special cone so constructed that the stream of water is visible, thus making it possible to know whether the relief valve is working properly. The cone and its connections are shown in Fig. 1. As an extra precaution, it is desirable to have a special boiler feed connection, so arranged that it can be used in case the regular feed is disabled.

Rotary Pumps

A typical rotary fire pump is shown in Figs. 8, 9 and 10. In a pump of this type the impellers or cams are a pair of specially designed gears interlocking and working together as shown. As these impellers revolve, the water is carried around and through by the teeth and forced out at the discharge outlet the same as in any displacement pump. Standard fire pumps of this type are made in four sizes for the same capacities as the duplex pump, and when new should be able to discharge at least 10 per cent in excess of their rated capacity against 100 lb. pressure at a speed not exceeding 300 r.p.m. They may be run, however, at the highest speed possible without causing violent vibration or hammering in the pipe system, as the matter of wear need not be considered during the short periods they are in operation.

The method of driving a rotary pump will depend somewhat upon local conditions. In some cases a motor having the same normal speed as the pump is employed, thus doing away with all speed reducers. If it is not practicable to drive direct cut spur gearing, or a silent chain drive may be used, depending upon conditions. When connected with the main shaft of the mill through

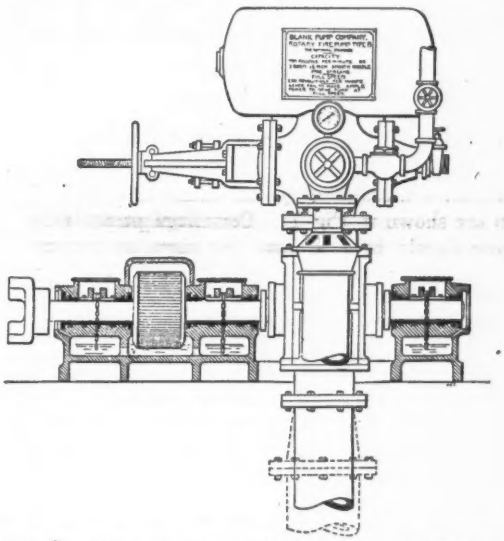


FIG. 9. SIDE ELEVATION OF ROTARY FIRE PUMP

spur gearing or silent chain drive, some form of friction clutch should be used so that the pump can be thrown into gear while the shaft is in motion. Chain drives should never be used in wet places. The older, and probably more common method of driving rotary pumps from the main shaft, is through a pair of friction gears. This does away with the necessity of a clutch, as the gears may be thrown into mesh while in motion.

When a pump of this type takes its water under a head, the suction pipe may be the same size as the open-

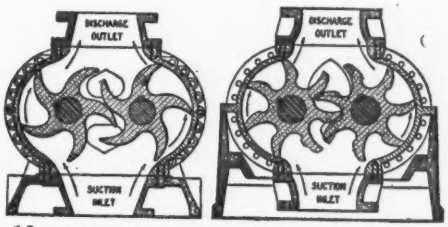


FIG. 10. SECTIONS THROUGH IMPELLER CHAMBER OF ROTARY PUMPS

ing given in Table III; but with a lift of 10 ft. or more and a length exceeding 20 ft. with two elbows, the pipe should be 2 in. larger than the pump opening. When the water is taken under a suction head, a priming tank of at least 200 gal. capacity must be provided.

A safety or relief valve, set to open at 100 lb. pressure, is provided and piped to a discharge cone similar to that already described. This valve should be of such size that the full volume of water handled by the pump may be discharged without raising the pressure above 125 lb. per sq. in. A special valved connection between

the discharge outlet of the pump and the discharge cone is provided for use when starting up. This valve should be opened until all air is forced out of the pump and a solid stream of water flows into the cone, when the valve

TABLE I. DUPLEX STEAM FIRE PUMP DATA

Gallons per minute	Diameter of steam cylinder in inches	Diameter of water cylinder, in inches	Length of stroke, in inches	Stroke per minute	Boiler Horse-power	Steam pressure at pump
500	14	7	12	140	100	40
750	16	9	12	140	115	45
1,000	18	10	12	140	150	45
1,500	20	12	16	120	200	50

is gradually closed and the pressure brought up to normal pressure without water hammer.

Centrifugal Fire Pumps

Sections through a typical 2-stage centrifugal fire pump are shown in Fig. 11. Centrifugal pumps for this purpose should have at least two stages and not more than four.

TABLE II. SIZES OF STEAM AND WATER CONNECTIONS FOR VARIOUS SIZE PUMPS

Capacity in gallons	Steam pipe, inches	Exhaust pipe, inches	Suction pipe, inches	Discharge pipe, inches	Number of 1-1/8 - inch fire streams supplied	Number of automatic sprinklers supplied
500	3	4	8	6	2	30 to 40
750	3½	4	10	8	3	45 " 60
1,000	4	5	12	8	4	60 " 80
1,500	5	6	14	10	6	90 " 120

The speed should not exceed 1800 r.p.m. except in special cases where the pump is driven by a steam turbine, in which case 2500 revolutions is allowed. As it is desirable to operate the pump, and motor or turbine, at the same speed without the use of gearing or other speed reducing methods of transmission, it is necessary to

TABLE III. STANDARD ROTARY FIRE PUMP DATA

Gallons per minute	Diameter of suction, in inches	Diameter of discharge, in inches	Rev. per minute	Horsepower (maximum)	Number of 1-1/8-in. fire streams
500	6	6	275	60	3
750	8	8	275	90	3
1,000	8	8	350	120	4
1,500	10	10	250	180	6

employ pumps designed for the speeds of standard motors of the sizes required.

The efficiency of a centrifugal pump falls away rapidly in the smaller sizes, so that it is necessary to assume a minimum efficiency in order to limit the size of motor and thus keep down the first cost of the outfit. Priming equipment, relief valve, starting valve, suction and discharge piping, etc., are much the same as for a rotary pump and do not need special description. A typical layout for a centrifugal pump is shown in diagram in Fig. 12. A priming tank of at least 250 gal. should be provided and connected with the discharge side of the pump.

TABLE IV. CENTRIFUGAL PUMP DATA

Gallons per minute	Dia. of suction, in inches	Dia. of discharge, in inches	Efficiency	Horsepower required
500	6	6	50 to 55	64 to 60
750	8	8	55 " 60	88 " 80
1,000	8	8	60 " 65	107 " 100
1,500	10	10	65 " 70	148 " 138

Centrifugal pumps are most frequently driven by direct-connected electric motors, in which case especial care should be taken that the source from which the current is obtained is thoroughly reliable and not likely to be interrupted.

Location of Pumps

Fire pumps of whatever type must be located so as to be safe from falling floors or machinery, and cutoff doors should be provided as a safeguard against smoke and fire which might drive away the operator. In general, a one-story building isolated from the main group is to be preferred. When brick or reinforced concrete is not possible, expanded metal and cement is recommended as an inexpensive and desirable construction for a pump room. In any case, the room should be of ample size to afford access for operating and overhauling, and

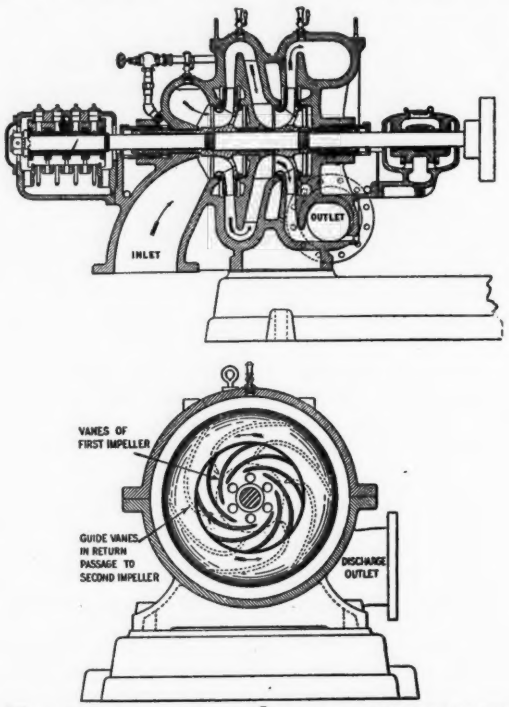


FIG. 11. SECTIONS THROUGH 2-STAGE CENTRIFUGAL PUMP

should never be used for storage purposes. Danger of freezing must be guarded against, and heat for this purpose is usually best provided by means of a steam coil. Fire pumps should not usually be placed in the engine room, as the escaping water is likely to injure the adjacent machinery.

Operation of Fire Pumps

In starting a steam fire pump, first open the priming valve and the four air cocks on the water cylinders, and provide a free vent through one of the hose valves, at the same time making sure that the drain cocks on the bottom of the water cylinders are closed. While the priming water is entering the water cylinders, the drips on the steam cylinders should be opened to clear them of all condensation. Start the oil lubricator and be sure that the valves in the suction and discharge pipes are wide open. When the cylinder is full of water, close the

priming valve, turn on steam slowly and increase the speed until solid water comes from the air cocks and the open hose valve. Then close all cocks and vents and bring the pump up to the required pressure of 80 to 100 lb. When running fairly, close the steam drain cocks and adjust the cushion valves so as to get full stroke and smooth action.

The pump should be kept in condition by running for a few minutes each week until water is discharged in a solid stream, at nearly full speed and pressure, through the relief valve or other convenient opening. The steam cylinders and valves should be kept in good order and free from rust by liberal lubrication. All parts of the pump should be inspected at regular intervals and the whole apparatus kept clean and in adjustment.

All that has been said in regard to the general care of a steam pump applies to the rotary type. In starting up a rotary pump, close the drain cocks, and prime the

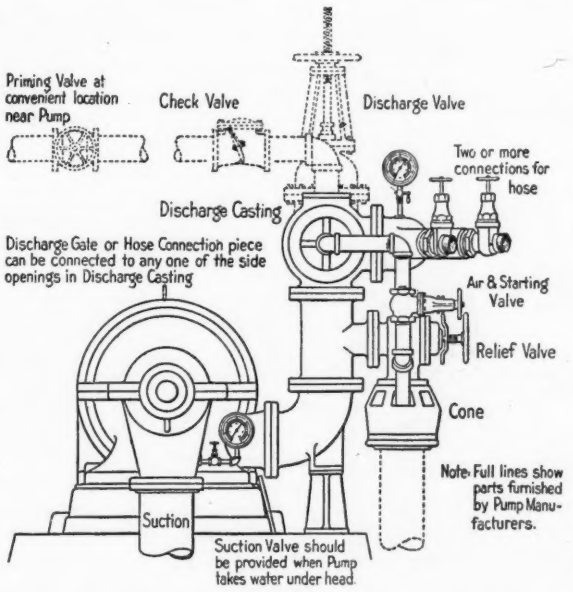

Priming Valve at convenient location near Pump
Check Valve
Discharge Valve
Two or more connections for hose
Discharge Casting
Discharge Gate or Hose Connection piece can be connected to any one of the side openings in Discharge Casting
Air & Starting Valve
Relief Valve
Cone
Note: Full lines show parts furnished by Pump Manufacturers.
Suction
Suction Valve should be provided when Pump takes water under head

FIG. 12. TYPICAL CENTRIFUGAL PUMP INSTALLATION

pump when water is taken under a lift. See that the suction and discharge valves are open and that nothing can interfere with the shafting or gearing. If driven by friction, the gears should be forced firmly into position and the mill shafting thrown out if there are clutches for this purpose. If the equipment is arranged for hand control, bring it up to pressure gradually as conditions may require; but if this is not possible, keep the pump at full speed and allow the excess water to escape through the relief valve.

The most common fault of a rotary pump is slipping of the friction gears. If these are clean and dry and properly set, however, there should be no trouble. Should slip occur during a severe fire, a little fine sand may be thrown in, but this should not ordinarily be resorted to. When there are no clutches for cutting out the main shafting, it may be necessary in case of a severe fire to cut the main belt in order to save power for the pump and to prevent fanning the flames.

A rotary pump should be turned over weekly to prevent sticking by rust, and also to see that the clutch or other method of driving is in working condition. Turn a small amount of heavy oil into the pump each time after it has been used with water and give the buckets a turn to spread the oil over the inside surfaces.

Much of the data and information contained in this article has been obtained from the various publications of the Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, and the National Fire Protection Association, to whom it is desired to give due credit.

Concrete Boards, Joists and Rafters

By Mark Meredith

BOARDS of concrete, with joists, rafters and stair-frames of the same materials, are used in the construction of a novel building in Los Angeles, Cal., the whole being set up on concrete. Though put together after the manner of a frame structure, the building is as fireproof and durable as the more common types of cement houses, but it requires less material and is lighter in weight.

The various parts are poured into forms on the ground near the site, and in that way the danger of breakage is eliminated. The clapboards are poured into sets of ten, the forms being securely clamped together, and the cement allowed to harden in them for several days. They are taken out then and allowed to cure before being set up. This is done while the preliminary work is going on, such as excavating and laying the foundation.

The joists, rafters and other parts are formed in the same manner, and various types of reinforcing are used for each. The boards are reinforced with wire mesh, while the timbers have iron rods of varying thicknesses to strengthen them. These are allowed to project at one end in order to fit into corresponding holes in other timbers, so that the whole framework dovetails. The method of attaching the boards to the 2 by 4-in. members is with nails, the holes being bored into the cement boards before they have set by running a wire through them. As the cement timbers will not take the nails, a strip of wood about 1½ in. thick is wired to the cement scantling.

Use of X-Ray for Examining Metals

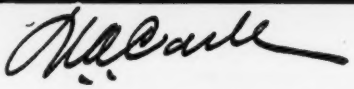
EXPERIMENTS have been made recently in France to discover to what extent the X-ray can be used to detect the interior defects in metals. The following results were obtained by M. Schneider, working in the Creusot laboratories: Detection of the number and position of the blow-holes in a test piece. Determination of the effects of the addition of aluminum and tungsten on the structure of steel, with the aid of the microscope. Production of photographs showing the interior structure of different alloys. Up to the present time, it has not been possible to use test pieces of greater thickness than about 1½ in.; but M. Schneider believes that by increasing the penetrating power of the rays, and also the sensibility of the plate, it will shortly be possible to examine pieces up to 7 or 8 in. thick.

IT IS reported from Berlin that at the first hide auction since October, 1914, held in that city recently, prices paid were two and three times war maximum.

NATHANIEL ALLEN CARLE

FROM DIVERSIFIED EXPERIENCES IN MINING, POWER INSTALLATIONS, RAILWAY ELECTRIFICATION, AND DAM BUILDING HAS COME A REMARKABLE ABILITY TO SERVE. AS CHIEF ENGINEER OF A LARGE POWER SYSTEM AND ACTIVE MEMBER OF A SCORE OF IMPORTANT ENGINEERING COMMITTEES, HIS WORK IS AMAZINGLY EFFECTIVE. BY E. B. MEYER

NATHANIEL ALLEN CARLE was born May 28, 1875, at Portland, Oregon. In 1881 he moved to Seattle Washington, where he received his elementary education in the public schools. Following this, he studied mechanical engineering at Leland Stanford, Jr. University, during which time he became a member of the Beta Theta Pi fraternity and of the Sigma Psi honor society. The physical side of his make-up was not neglected during this formative period, as was evidence by the fact that he played for three years on the varsity football team.



Graduating from the university in 1898, Mr. Carle at once became associated with the Silver Bow Mining Co. at Juneau, Alaska, where, with that thoroughness for which he has since been noted, he worked underground as a miner for the purpose of acquiring practical knowledge in mining.

In 1899, Mr. Carle was employed by the Canadian Rand Drill Co. at Sherbrooke, Quebec. Upon coming to New York in 1900, where he was connected for some years with Westinghouse, Church, Kerr & Co., Mr. Carle was assigned to work of unusual importance for a young man, his first work for that organization being the installation of a power plant in the Back Bay Station of the New York, New Haven and Hartford Railroad at Boston. Later, as field engineer on the construction of the Kingsbridge Power Station, for many years the largest and most economically operated power plant in New York, marked evidence of his ability was shown. The same can be said of him as first assistant to the Superintendent of Construction on the Long Island Power Station of the Pennsylvania Railroad at Long Island City and on all Long Island Railroad electrification.

In 1906, Mr. Carle was sent by Westinghouse, Church, Kerr Co. to Denver, Colorado, as engineer in charge of work on the construction of a large power plant at the coal fields and on the electrification of the railroad between Denver and Boulder for the Northern Colorado Power Co. Here his work impressed the power company so favorably that he was induced in 1907 to undertake also the duties of vice-president and general manager of that company.

In 1909 Mr. Carle returned to Seattle, where he opened an office as consulting engineer, becoming actively identified with numerous enterprises of the State Board of Control of the State of Washington, and paying considerable attention to dam construction of the Ambursen type, being associated in this connection as engineer for the Puget Sound & Dredging Co. His withdrawal from the field of private practice, while contrary to his personal desires, was due to the insistence on the part of the Public Service Electric Co. of New Jersey that he become its chief engineer. In this latter capacity Mr. Carle was called upon to enlarge and reorganize the engineering force of the company, and has since been in charge of the branches of engineering and construction work required by this great company. This has included the design and construction of severable notable power plants in which economy in cost and operations has been such as to occasion much admiration on the part of other engineers.

The Public Service Electric Co., of which Mr. Carle is chief engineer, furnishes electricity for domestic and municipal use in approximately 200 municipalities in the State of New Jersey. During the war the company supplied light and power to over 150 industrial plants engaged directly or indirectly in the manufacture of war munitions. It operates 18 generating stations having a total capacity of 270,000 kw., and 100 substations are supplied with power over the company's system of network, consisting of 850 mi. of overhead and underground transmission circuits, operating at 13,200 and 26,400 v.

Mr. Carle is an interested and active member of numerous engineering societies. In the American Institute of Electrical Engineers, of which he is a fellow,

vice-president and director, he also serves on the following committees: Finance, Headquarters, Executive, Public Policy, Publication, and Joint Finance Committee of Founder Societies.

The Engineering Council is an organization of National Technical Societies of America, created to provide for consideration of matters of common concern to engineers, as well as those of public welfare in which the profession is interested, in order that united action may be made possible. In the work of the Council, Mr. Carle represents the American Institute of Electrical Engineers, is chairman of the Finance Committee, and a member of the Rules Committee.

The American Standards Committee is perhaps one of the most important present day activities of American engineers, and on this committee Mr. Carle represents the American Institute of Electrical Engineers and is a member of the following: Committee on Constitution and Rules of Procedure, Special Committee to Consider Proposed Constitution, Committee on Technical Co-operation with the Institution of Electrical Engineers of Great Britain.

In the American Society of Mechanical Engineers, Mr. Carle is active as a member of the Power Test Codes Committee and as chairman of one of the sub-committees.

As vice-chairman of the Technical and Hydroelectric Section of the National Electric Light Association and as chairman of the Prime Movers Committee, Mr. Carle is taking a prominent part in the work of that organization.

Though more particularly engaged at this time in electrical and mechanical engineering, Mr. Carle has for many years been a member of the American Society of Civil Engineers.

He serves the Association of Edison Electric Illuminating Companies as a member of the Steam Plant Committee.

Personally, Mr. Carle is a man of great vital power and strong character, possessing marked administrative ability and combining to an unusual degree the faculty of applying in a practical way original and fundamental engineering. To these attributes must be added a genial disposition, which has enhanced the regard in which he is held.

Mr. Carle's lifelong love for outdoor activities, to which, in college days, the football field afforded expression, now, under the limitation of city life, finds an outlet in gardening. Such hours as can be spared from a busy career for recreation are given to this wholesome work with his characteristic vigor and enthusiasm.

Factors Governing the Advisability of Using Superheated Steam

Ranges in Steam Consumption by Prime Movers. By A. H. Randolph

IN DISCUSSING this subject, let us take each factor separately without consideration of its relation to the other factors. This is actually the only way this subject can be discussed because no two plants present the same conditions and there can, therefore, be only a general relation of the different factors. In discussing these facts, it will, of course, be necessary to show how superheating results in improvment in plant economy and why.

Fuel Cost

THIS FACTOR is one which is the most obvious, particularly to the plant owner. On it depends in a large measure the cost of the finished product, because power costs in many cases represent a large percentage of the manufacturing costs and fuel costs in many cases are as high as 75 per cent of the cost of producing power.

Fuel must be accounted for, particularly when its cost is high. Superheating, correctly applied to meet the conditions existing in that plant, will increase the utility of the fuel by reducing its consumption. Depending on conditions, this saving may be from 6 to 20 per cent.

Engine Performance

AS FUEL consumption is the direct result of water evaporated and evaporation depends on the steam demands of the engine, it would be well to compare the steam consumption of different types of engines using saturated steam (under average plant conditions) with those using superheated steam at 100 deg. and at 200 deg. The following table shows average conditions.

Depending on the efficiency of the engine itself, it will be seen that superheating shows substantial economies in steam consumption. It should be noted also that the percentage of savings varies from 9 to 33 per cent for 100 deg. superheat to from 19 to 38 per cent for 200 deg. superheat.

Maintenance

ONLY WHEN conditions existing in a plant have been properly and thoroughly studied, can recommendations be made as to the degree of superheat which can most advantageously be used. On this depends the cost of labor and maintenance. In a properly designed superheater, figured for the plant conditions where it is to operate, the maintenance of the superheater should be no higher than the boiler maintenance cost. The maintenance of the boiler itself is reduced by the addition of the superheater because superheating actually increases the capacity of the boilers, and in a battery of superheated boilers it adds sufficient extra capacity to allow of drawing the fire and resting a boiler. The other boilers will still have sufficient capacity to carry the load economically. Each boiler can be cut out at regular intervals

RANGES IN STEAM CONSUMPTION BY PRIME MOVERS

Type Engine	Steam Consumption, lb. per hp. hr.		
	Saturated Steam	100 deg. superheat.	200 deg. superheat.
Simple non-condensing	29-45	20-38	18-35
Simple non-condensing automatic	26-40	16-34	16-30
Simple non-condensing Corliss	25-35	18-30	
Compound non-condensing	19-28	15-25	13-22
Compound condensing	12-22	10-20	9-17
Simple duplex steam pumps	120-200	80-160	
Turbines non-condensing (kw.hr.)	28-60	24-54	21-48
Turbines condensing (kw.hr.)	12-42	10-36	9-34

and the operation of the entire plant improved. This practice will enable a plant to hold a boiler in reserve. The result will be that all the boilers will last longer, and their maintenance cost will thereby be reduced.

Labor

In the selection of a superheater the item of labor should be carefully considered. It should be of such design that it can be maintained by the usual boiler room help and should not require skilled boiler makers with special tools to attend to its adjustment or keep it tight.

There is still another phase of the labor situation which is indirectly affected by superheating. Labor is often the largest item in manufacturing cost, and because a general wage reduction seems improbable, its unit cost can be reduced only by increasing its productive efficiency. No man can work as consistently or as rapidly as a machine, but man supplies the brains lacking in the machine. Brains plus machine is an irresistible combination. Labor-saving economical machinery will reduce labor costs through greater and better production. Machinery, however, requires power; and power, fuel. The unit cost of labor, therefore, can be reduced only at the expense of increased unit power cost. Right here we see the necessity of reducing fuel costs caused by increased power demand. We have already seen that superheating actually does reduce the fuel consumption and thereby cuts the fuel bills.

Capacity of Plant

The factor of insufficient plant capacity is one which often faces a power plant operator. We have seen that superheating decreases the steam consumption of the engine, which decrease may be attributed to the fact that superheating eliminates cylinder condensation and insures absolutely dry steam reaching the engine. The decrease in steam consumption where superheat is used, results in a steam reserve which can be utilized in the engine to take care of its overload capacity, should an additional power demand be required. Superheat furthermore increases the boiler capacity. This fact has been brought out previously.

There is still another point in connection with plant capacity which logically comes up in considering the factors which govern the use of superheated steam. Cases are cited every day where, because of the condition of a boiler, the insurance company requires that it be operated at a lower pressure. Loss in capacity results, and that plant faces the necessity of adding a new boiler. Superheating makes up the loss in boiler capacity when a plant is forced to reduce the boiler operating pressure. Furthermore, the engine operating on superheated steam will furnish more power, even under a reduced pressure, than it would if using saturated steam. In other words, superheating will enable a plant to operate economically and at its original capacity at a reduced pressure.

Steam Line Losses

The problem of reduced condensation in long pipe lines is one which is faced in many plants. In the generation of steam, 9/10 of the heat necessary to evaporate water is latent heat. When steam is condensed without doing work the latent heat is liberated and wasted. Condensation in long pipes is an absolute waste of 9/10 of the heat in the steam condensed. Superheat is necessary to raise the temperature of the steam to a point where all of the steam can be transmitted to its destination without condensation losses. The heat loss in transmitting superheated steam in covered pipe is actually less than in saturated steam because superheated steam does not give up its heat as readily as saturated steam, and furthermore, more heat can be taken from superheated steam before condensation begins. Superheated steam, therefore, is a means to eliminate condensation losses in steam pipe lines.

First Cost

Regardless of all other factors entering into a consideration of superheat, the factor of first cost will undoubtedly always be considered. In considering this it must be borne in mind that it is absolutely essential that all the conditions in a plant must be carefully studied by the superheater manufacturer, who should render an unbiased and accurate opinion as to the merits of superheating. In this way, the plant owner can know with certainty just what returns he can expect from his investment. It isn't a question which can be answered in general by the size or type of plant. It depends absolutely on the conditions which exist or which are desired in the plant whether or not the plant owner is justified in going even to the nominal cost of the installation of a superheater.

The possible economies with superheat depend on how far a plant is already economically developed. In many cases, installations are known to have paid for themselves in the first few months of operation.

R. A. H.

Young America

By Chas. H. Stephen

A coil of springs, a bag of hops;
A spinning wheel that never stops.
An ever bubbling spring of hope;
A sweet-toned human "calliope."
A battery with sizzling spark;
A live interrogation mark.
A mount of michief, mostly clean;
A scrapper that is rarely mean.
A medley blithe of laughs and kicks;
A soul-inspiring box of tricks.
The cutting edge of Nature's knife;
The heart that pumps the blood of life.
The busy bee of flowering June,
Whose buzz is never out of tune.
An ever-yielding mine of mirth;
The joy-producer of the earth.
A pleasant taste upon the tongue
Of age that tends to keep it young.
The joy of each real human heart,
Of this world's goods—the better part.
The sweet reminder of our past;
The die in which the future's cast.
The puzzling actor of the home;
An individual hippodrome.
A restless mass of energy;
The problem of humanity.
A boundless ocean filled with cheer
That makes life worth while living here.

Steam Pipe Support

SCIENTIFIC DETERMINATION OF PROPER SPACING OF HANGERS. CHARTING OF NECESSARY WORKING EQUATIONS. BY H. M. BRAYTON

THE question of steam pipe support is a vital one and should receive careful consideration from the designing engineer. The life of a steam piping system depends to a large extent upon the stresses which it is obliged to withstand, and these in turn are dependent upon the internal pressure and the distance between supports. Altogether too many steam designers space their hangers by their own judgment, in which case they have really very little idea of the amount of stress in the pipe. If a little time were taken to calculate these stresses properly, some surprising results might be obtained.

For the young engineer who is lacking in years of practice, it is always the best policy to calculate everything that can be put on a mathematical basis. In this way he is playing safe and the profession as a whole is thereby put upon a more scientific basis. It seems to be the practice of many engineers to make every effort to forget as quickly as possible all the theory which was absorbed in the technical school. How much better it would be if they would cultivate the habit of applying the theory to practice. After all, is there really much

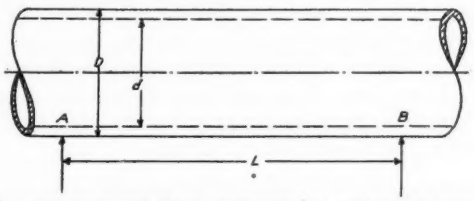


FIG. 1. SECTION OF PIPE SUPPORTED DIAGRAMMATICALLY AT TWO POINTS

difference between theory and the practical application of applied science?

In this article, the writer wishes to show how the stresses in the steam pipe line may be determined, or conversely how the proper span may be found when the maximum stress to be permitted is fixed upon. That the method described involves nothing new, except the application of this theory in a way which will make calculation easy and rapid, is the thing which the writer wishes to emphasize here.

Generally speaking, there are two factors which cause stress in steam pipes: first, the stress due to the internal pressure of the steam; second, the stress due to the weight of the pipe under beam action. The former stress is in the form of a hoop tension and acts in a plane perpendicular to the axis of the pipe. The beam stress is longitudinal. We must deal with these two stresses separately and then combine them, as will be shown later, in order to obtain the actual stress in the metal.

In calculating the stress due to the weight of the pipe under beam action, we must make provision for a condition which, while it happens but rarely, nevertheless does occur. We refer to the possibility of the steam pipe filling with water. Steam systems have been known to fail with disastrous results because this possibility was not considered. The weight of steam which will be required to fill the pipe at even high pressure is a negligible quantity, but the weight added when the steam is displaced by water is considerable. We shall then take this condition into account when calculating our stresses and spans.

Steam pipe is made in various sizes and thicknesses of metal. Furthermore, they are made of steel as well as cast iron, two metals which differ markedly in their physical characteristics. We must then develop our mathematics to include a fiber stress factor, because a value which would be suitable and safe for steel would be dangerous with cast iron pipe. Let us drive some general formulas which will apply to either metal and to any size. These general formulas will, of course, simplify when applied to a limited case.

We would now refer the reader to the sketch shown in Fig. 1. Here we have a section of an ordinary steam pipe supported at the two points A and B, a distance

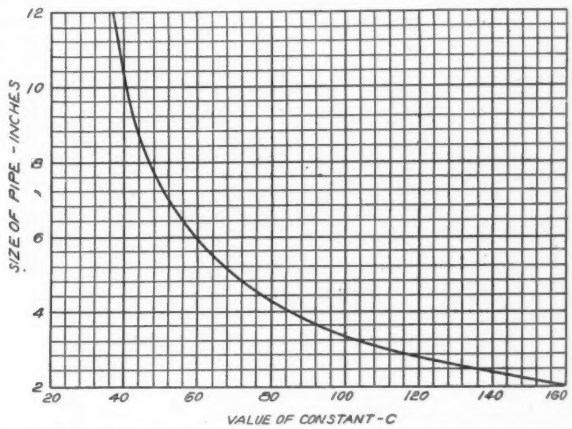


FIG. 2. VALUE OF CONSTANT C FOR EXTRA STRONG WROUGHT PIPE

of L feet apart. The inside or nominal diameter of the pipe is d inches and the outside diameter D inches. The weight per foot, including flanges, may be approximately expressed by the equation

$$W' = 2.75\ (D^2 - d^2)$$

and the weight per foot of the water in the pipe by

$$W'' = 0.34\ d^2$$

from which we obtain the total weight per foot to be

$$W = W' + W'' = 2.75\ (D^2 - d^2) + 0.34\ d^2$$

which will simplify to

$$W = 2.75\ D^2 - 2.41\ d^2 = 2.41\ (1.14\ D^2 - d^2) \qquad \text{(Eq. 1)}$$

in which W equals the total weight of water and pipe per foot of length expressed in pounds.

FUNDAMENTAL BEAM LAW

STRICTLY SPEAKING, we have in the case of the steam pipe a continuous beam supported from a long string of hangers. In such a condition, the three moment equations for a continuous beam would apply. These equations are very complicated and are furthermore seriously affected when the supports vary at all from the same elevation. These two factors make the application of the

three moment equations to this problem impractical. For our purpose, it will be sufficiently accurate to consider the pipe as a beam having a uniformly distributed load and supported at the ends. The fundamental law

$$F = \frac{M\,Y}{I} \qquad \text{(Eq. 2)}$$

will apply nicely. Here F = maximum fiber stress, M = maximum bending moment, I = the moment of inertia in respect to the axis of the pipe and Y = the distance to the most strained fiber which in this case is the outside radius or one half the outside diameter of the pipe.

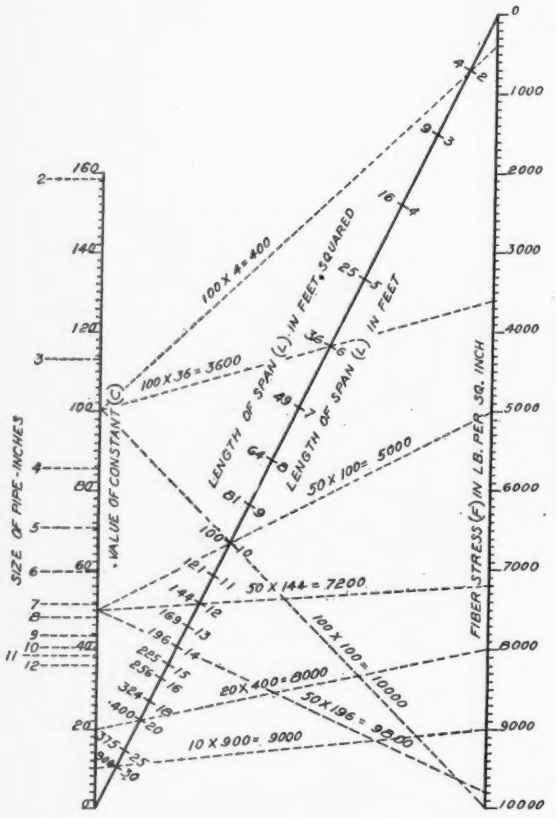

SIZE OF PIPE-INCHES
VALUE OF CONSTANT (C)
LENGTH OF SPAN (L) IN FEET, SQUARED
LENGTH OF SPAN (L) IN FEET
FIBER STRESS (F) IN LB. PER SQ. INCH
100 X 4 = 400
100 X 36 = 3600
50 X 100 = 5000
50 X 144 = 7200
100 X 100 = 10000
20 X 400 = 8000
50 X 196 = 9800
10 X 900 = 9000

FIG. 3. CHART FOR FIGURING LENGTH OF SPAN OR FIBER STRESS

The moment of inertia is expressed by

$$I = \frac{3.1416\,(D^4 - d^4)}{64}$$

and the maximum bending moment by

$$M = \frac{144\,W\,L^2}{8}$$

in which M is expressed in inch units and L, the length of the span, in feet. With these values it is possible to substitute in equation 2 as follows:

$$F = \frac{M\,Y}{I} = \frac{144 \times 64\,W\,D\,L^2}{8 \times 2 \times 3.1416\,(D^4 - d^4)}$$

and we may further substitute the value of W as found above and obtain:

$$F = \frac{144 \times 64\,D\,L^2\,2.41\,(1.14\,D^2 - d^2)}{8 \times 2 \times 3.1416\,(D^4 - d^4)}$$

or

$$F = \frac{442\,D\,L^2\,(1.14\,D^2 - d^2)}{(D^4 - d^4)} \qquad \text{(Eq. 3)}$$

Equation 3 is somewhat complicated, yet it contains but four variables. This equation applies to all sizes and classes of pipes and will give the maximum fiber stress due to bending only. The equation as it stands is too complicated and involves too much work to be practical. For any given set of conditions, however, it can be greatly simplified and then quickly solved by means of a graphical chart. Why not write this equation 3 as follows?

$$F = C \times L^2 \qquad \text{(Eq. 4)}$$

in which C is a constant and given by

$$C = \frac{442\,D\,(1.14\,D^2 - d^2)}{(D^4 - d^4)} \qquad \text{(Eq. 5)}$$

and for any given class of pipe a table may be worked out showing the value of this constant C for the different sizes under this class. In the usual run of such work any one engineer rarely has occasion to use all kinds, and he can quickly work out this table for such classes and sizes of pipes as he uses in his work. As an illustration of this, the values of this constant for "extra strong" wrought steel pipe is given in the accompanying table. With this constant and equation 4, the value of the fiber stress F for any span L can readily be determined, or conversely the proper value of L to use and not exceed the predetermined stress.

VALUE OF CONSTANT C FOR EXTRA STRONG WROUGHT PIPE

Size, inches	Outside diam. D, inches	Inside diam. d, inches	Value of Constant C
2	2.37	1.94	158.6
3	3.50	2.90	113.0
4	4.50	3.83	85.5
5	5.56	4.81	70.2
6	6.63	5.76	59.7
7	7.63	6.63	51.6
8	8.63	7.63	48.0
9	9.63	8.63	43.5
10	10.75	9.75	40.5
11	11.75	10.75	38.3
12	12.75	11.75	36.0

It may be found more convenient to put this information in the form of a curve with the size of pipe plotted against the value of the constant. Such a curve is shown in Fig. 2. The drop in the value of the constant as the size of pipe increases is very marked. This means that with the same span L, the value of the stress F decreases rapidly as the size of pipe increases. For the same stress, therefore, the larger the pipe, the longer the span can be made. This fact is well known to practical men.

With the value of the constant determined for the size of pipe being considered, the next step is to determine the span for a certain stress, or the stress for a certain span. This is given by equation 4. In order to simplify the calculation, we can put this formula into a

graphical chart, because it is of the simple three variable type of the product form. Such a chart is given in Fig. 3. Two cases arise, one in which the maximum length of span is desired, in which case the maximum allowable fiber stress must be decided upon, and the other in which the maximum fiber stress which will be produced with a certain span is the thing desired. This chart will solve either case. In fact, any one of the three variables may be solved for when the other two are known.

The dot-dash line shows how to use the chart. In the illustration we have assumed a standard extra heavy 6-in. pipe and a span of 10 ft. The chart shows the value of 6000 lb. per sq. in. on the fiber stress scale. In a similar manner, the length of span or size of pipe may be solved for.

It will be remembered that this curve, Fig. 2, and chart, Fig. 3, are built up only for "Extra Strong" wrought pipe. It will not apply for any other class. The writer wishes to bring out here only the method of attacking this problem so that the reader may work it out for the particular work he may be called upon to do. In order that the reader may do this it will be necessary to give here some of the theory of the chart given in Fig. 3. Consider now the three variables, C, L and F, and the relation between them given by equation 4. It is assumed that the reader has first worked out the value of the constant C from equation 5 for the particular class of pipe. Next decide upon the maximum values of C and F. The writer has chosen these 160 and 10,000, respectively. With these limits settled upon we may proceed to construct the chart.

Draw two parallel lines about 5 in. apart, Fig. 4 C 8 in. long and F 10 in. long. Graduate line C from the bottom up so that each inch represents 20 on the scale; this will be the scale of constants. Draw a straight line from zero on scale C to the top of line F and graduate line F from the top down into tenths of an inch each inch representing 1000 on the scale of fiber stress. The next step is to graduate the diagonal. From the nature of the Z chart we know that with simple scales the value given in scale C times the value in the diagonal will give the value in scale F, however, the diagonal scale in this case is not to be the simple scale as ordinarily used for Z charts but the square root of that scale, so we shall graduate the diagonal according to the squares of the lengths we wish to consider, these being as shown on the finished chart.

To do this graphically, we select some easily calculated figure such as 100 in scale C; multiply this mentally by 2^2, giving 400. Then placing the ruler from 100 in scale C to 400 in scale F, we draw a short line across the diagonal and mark it 2 as the length of span in feet. Continue this process, using 100 in the C scale until the end of the F scale is reached. Then select some new value such as 50. This can also be worked mentally, as you can divide your calculations with 100 by 2 and get the same result: thus, $100 \times 11^2 \div 2 = 6050$ and $100 \times 14^2 \div 2 = 9800$. When the limit of scale F is again reached, we can select 20 and 10 as calculating points in scale C; but as the squares of numbers above 14 are not so easily remembered, it may be necessary to carry these calculations out on paper, but in this case we have only five of these.

Having graduated the diagonal, the next step is to refer to Fig. 2 or the table and plot the size of the pipe at its constant value in the scale C.

Thus we have 2 in. at 158.6 in scale C, and on to 12 in. at 36 in scale C. In completing the chart, we omit the unnecessary scales leaving only the size of pipe, length of span in feet and fiber stress in pounds per sq. in. We are then able to solve the problem by placing the straightedge once across the chart.

The chart, once made, will save many hours of calculation or eliminate the danger of guesswork when calculation is not resorted to. The whole problem will thus be put on a sound scientific basis.

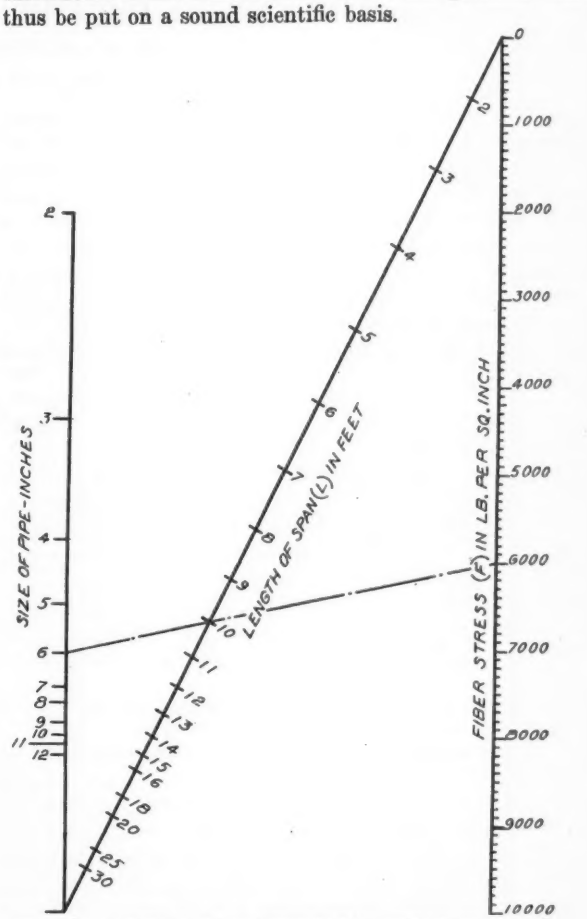


FIG. 4. METHOD OF CONSTRUCTING CHART IN FIG. 3

The reader must bear in mind that the values selected above apply only to this particular problem. He must select those which best suit his own problem, and he should be able to do this with the fundamental principles given above. The designer may be willing to allow a greater fiber stress than that given by this chart, or he may be dealing with larger pipe.

To sum up, therefore, this problem of determining the proper distance between steam pipe supports resolves itself into first knowing the kind of pipe which is to be used, then determining the value of the constant from equation 5, setting a maximum allowable value for the fiber stress and solving for L in equation 4. If a chart has been made for this class of pipe, it becomes a very simple problem because it is only necessary to find the size of pipe and from this point connect with the

value of the fiber stress desired and the length of span, L, will be shown on the diagonal scale. The whole solution will require but a few seconds, and the designer knows that he is playing safe.

The foregoing discussion and formulas give the method of finding the stress due to beam action only. There is another cause for stress in a steam pipe and that is the internal pressure of the steam. This is a separate problem and will be discussed in a later article. The two stresses, that due to beam action and that due to pressure, must be combined vectorially in order to obtain the actual magnitude and direction of the resulting stress. The former stress acts longitudinally, while the latter acts as hoop tension, the two being at right angles to each other.

The actual amount of deflection which may be expected from a steam pipe when supported in the usual way is often an important problem, and this will also be discussed in a later article. Simple methods of obtaining this deflection will be given.

The Steam Engine Indicator Diagram---I

Its Significance. Analysis of the Admission and Steam Lines

AS A GUIDE post to engine performance, the steam engine indicator is an indispensable piece of equipment for power plants using steam engines as prime movers. It tells what the valves are doing and how they are synchronized. It shows up any leaks in the mechanism, and, if the cards are laid out and scaled, they give a true indication of the horsepower developed. The subject has been gone over many times before, but it is one which bears repeating, due to the possible saving out on the coal pile, which the use of an indicator may effect.

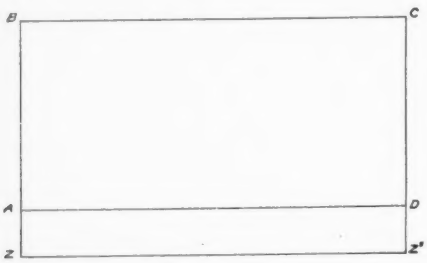


FIG. 1. THEORETICALLY PERFECT DIAGRAM

In this article the diagram will first be considered as a series of lines, and then the practical cards will be studied from the standpoint of correcting engine imperfections. Assuming that the indicator has been applied, the motion set up and actual card taken, it is worth while to consider the simplest and most elementary form of diagram. Referring to Fig. 1, AD represents travel of the piston, reduced, and ZB the absolute steam pressure. Line ZZ′ is the no-pressure line which is used for condensing units, while AD is the atmospheric pressure line used in noncondensing units.

Suppose the piston is at point Z and the cylinder pressure (absolute) instantly rises to an amount indicated by ZB. This moves the piston to the right with a constant pressure along BC. At C a sudden condensation or emission of steam takes place and the pressure drops back to Z′, leaving the piston to travel back toward Z under the impulse of the flywheel or steam pressure on the opposite side of the piston. This cycle is for an engine running condensing. Without the condenser, the same events take place, except that the pressure rise and drop are measured from AD instead of ZZ′, which indicates practically 14.7 lb. To move the piston against atmospheric pressure, an amount of work equal to ADZ′Z must be done, and the area equal to ABCD is the actual effective work for one stroke.

All of this applies to an engine which is impractical to construct, because of the instantaneous rise of pressure, its continuance throughout the stroke, and finally its immediate drop back to atmosphere or vacuum. The principle, nevertheless, holds true and serves as a simple illustration. Practically, a card as illustrated in Fig. 2 is obtained. ZZ′ is the vacuum line and AE the atmospheric line. With the piston at A or Z, the valve opens and the whole steam chest pressure is obtained in the cylinder as indicated by AB or ZB. This is held constant by that part of the stroke indicated by BC, until, at point C, the inlet valve closes and the pressure gradually decreases as the piston moves forward and the steam increases in volume. This expansion and pressure drop follows a true law: In any container which is subject to a variation in volume, with no loss of gas or change in temperature, the pressure times the volume at any instant is always constant. This holds theoretically only, and it is readily understood that this condition is not attainable in steam engine practice. The

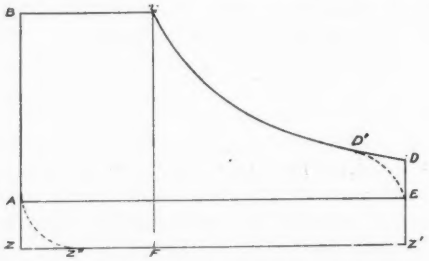


FIG. 2. PRACTICALLY PERFECT DIAGRAM

tendency toward this form of expansion exists, however, and some expansion curves very closely approximate it.

When the piston arrives at a point in the line indicated by D, the exhaust valve opens and the pressure drops to an amount equal to DE or DZ′, after which the return stroke is made up to point A or Z, where steam is again admitted and the cycle repeated.

Ordinarily the point of release is at about D′ and the pressure gradually drops along the dotted curve, to Z′. In passing through Z″, the exhaust valve closes, and a gradual compression of the remaining steam takes place until A is reached, at which point the steam chest pressure again acts and runs the line straight up. Thus an ideal card is formed.

The Admission Line

Diagnosing just what happens in the cycle is done to best advantage by considering the various parts of the diagram in detail. The steam line A, Fig. 3, indicates good operating conditions. There is a slight variation from the vertical, indicating that the steam chest pressure is instantly effective on the piston after compression, this taking place at the proper time.

B and C show premature admission; the piston is not yet in proper position for the inlet valve to open. The small hook on C is caused by the piston forcing some of the steam back into the chest just before it reaches the end of its stroke. The pressure drop when a piston starts back again is indicated by the lower part of the hook. D, E and F show excessive compression. In D the hook intersection is made considerably before the piston is at its maximum stroke. This pressure continues to rise until the maximum height is reached at the end of the stroke, at which time the inlet opens and the pressure drops to that of the steam chest. This, it will be seen, is less than the compression, a condition which is not desirable. In E compression occurs later in the stroke, while at F, compression, steam admission and the end of the stroke occur almost simultaneously. Peaks due to the momentum of the indicator parts

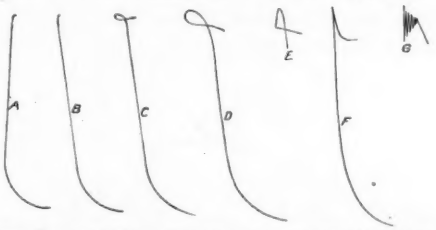


FIG. 3. VARIOUS FORMS OF ADMISSION LINES

sometimes appear, but these are usually irregular in their nature, due to the vibration of the indicator, piston, lever, etc. Such a case is shown at G.

Late admission gives lines as shown in Fig. 4. A small amount of compression and tardy admission are reached in the varying degrees by A, B and C, while in D a fair compression and very tardy admission occurred, the valve not actually opening until the lowest point of the loop was reached. This condition is shown to a more marked degree at E.

Where separate steam and exhaust valves are used, as in the Corliss engine, the condition F often occurs. Here the inlet opens before the exhaust closes, allowing live steam to pass through the cylinder, doing absolutely no work. Under conditions of negative lead, and the exhaust closing as the stroke ends, G is formed, in which the loop is made by the pressure drop as the piston moves in reverse direction until steam is admitted. Then the line rises as usual.

The Steam Line

In addition to maintaining a vertical admission line, it is quite as important to maintain a horizontal steam line. This indicates that the steam chest pressure is acting through the valves and on the piston until the point of cutoff is reached, from which expansion and a reduction in pressure take place.

Many conditions in steam conductors and engine designs tend to pull this line down after the point of maximum pressure has been reached. Slowly operating valves, too small steam chests, small, long and irregular steam ports, all prevent a rapid flow of steam into the cylinder after the piston has reversed and starts to increase the cylinder volume. To maintain a horizontal line, this area must be filled to a constant pressure as fast as it increases. It is evident, therefore, that high piston speeds mean high steam velocities. The valves must be so set and designed that they will not interfere with the required rapid flow of steam. Solid lines in Fig. 5A indicate the conditions as obtained with a piston speed of 300 ft. per min. and dotted line with a piston speed of 900 ft. per min., the valve setting being unaltered.

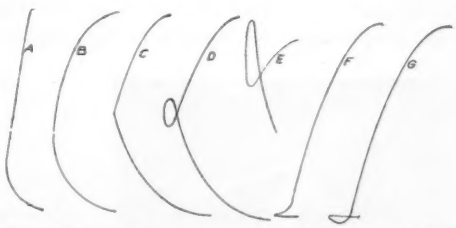


FIG. 4. ADMISSION LINES, SHOWING LATE ADMISSION

Figure 5B represents ideal conditions of steam inlet and cutoff which are very nearly approached in the Corliss engine, while Fig. 5C represents the ordinary valve action, the valve starting to close at a, and closing at b. Its comparatively slow movement causes a drop in pressure as the piston advances, because steam cannot enter the cylinder rapidly enough. Had the valve action been instantaneous, an additional amount of work equal to the area abc would have been done.

Figure 5D was taken from an engine on which the steam chest was large enough to act as a reservoir. From a to b pressure dropped, due to slow valve action; but when the full port opening was available for steam flow,

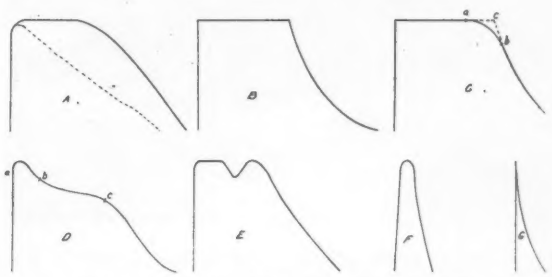


FIG. 5. VARIOUS FORMS OF STEAM LINES

the pressure again became constant from b to c, even under the influence of an advancing piston. This was because the steam chest acted as a receiver and was large enough to take care of the demands made upon it.

Sensitive governors or poorly operating dashpots are apt to cause a re-opening of the inlet valve and produce a steam line similar to Fig. 5E. Exceptionally early cutoff will produce nothing more than a curve peak, as Fig. 5F, and when a condensing engine is run with no load, enough steam can be admitted into clearance space to overcome bearing friction and keep up operation. In this case a sharp peak, as Fig. 5G, is produced.

The analysis of the remainder of the diagram will be taken up in the next article.

The Lea Coal Meter

By J. H. Blakey

THE Lea coal meter, as the name indicates, is an apparatus for determining the amount of coal being used on the grate of a boiler during any given period of time, thus enabling the engineer to arrive at a close approximation of the efficiency of the boiler, under any and all conditions. Figure 1 shows the meter installed on a boiler fitted with mechanical stoker. Figure 2 is a diagram showing the different parts of the meter. The gears, C, moving with the grate, carry the drum or cylinder, G, which is shown in larger scale in Fig. 4.

An examination of the way in which the teeth on this drum are arranged will make it evident that a pinion

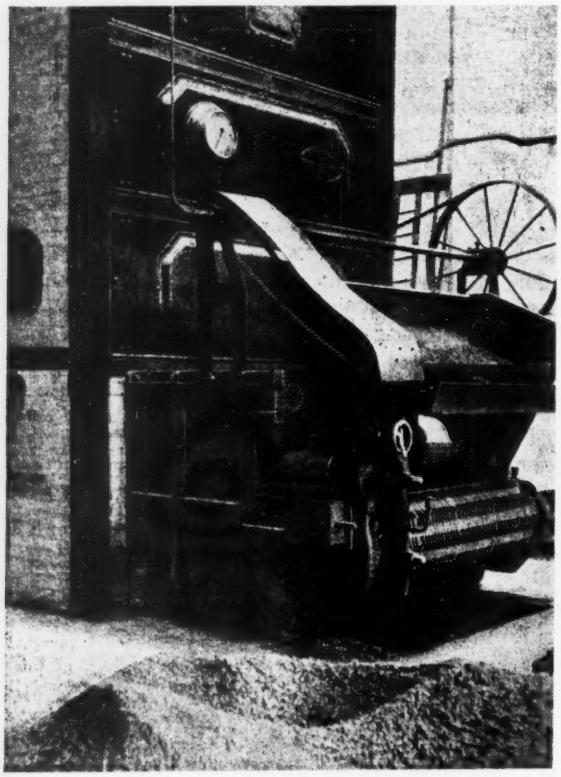


FIG. 1. METER INSTALLED ON A STIRLING BOILER WITH MECHANICAL STOKER

at one end will engage all of the teeth, and at the other end will not engage any, and also that the number of teeth engaged will decrease as the pinion passes from left to right. The movement of the pinion which brings about this result is produced by the connection of the pinion shaft with the hopper gate, O. This gate is counterbalanced by the weight, P, so as to give the shaft free movement between the guides, M, M. It will be noticed that the upper drum is completely toothed, and that it drives the indicator pinion, J. With this arrangement, any movement of the door, O, will affect the position of the pinion, I, and thereby increase or diminish the movement of the meter pinion, J. In practice, the lateral movement of the pinion, I, is reduced by the rack and pinion arrangement shown in Fig. 3, in which the chain, D, is attached to the hopper door.

Figure 4 shows the application of the meter to a boiler fed intermittently. In place of the movable pinion in Fig. 2, the indicator of the meter is moved laterally

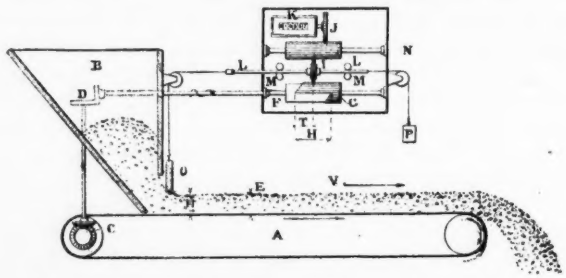


FIG. 2. DIAGRAM SHOWING CONNECTIONS OF METER AND GRATE

along the line of the axis of the partly toothed drum by means of the chain, L. It will be seen that the stroke of the plunger, A, is regulated by the position of the pin, D, which in turn is controlled from the screw bracket, C. As the chain, L, is attached to the top of C, any move-

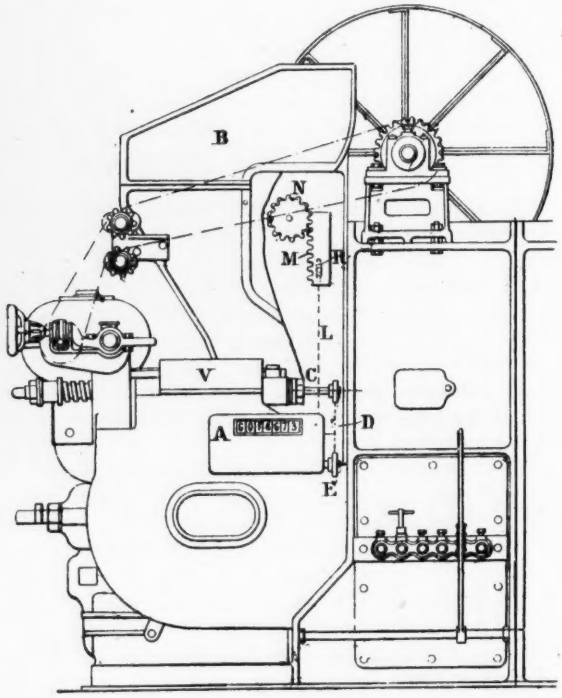


FIG. 3. APPLICATION OF THE METER TO A BABCOCK & WILCOX BOILER

ment of the pin, D, which increases the throw of the plunger, will also bring the indicator pinion, I, to a position on the drum in which a larger number of teeth will be engaged. Thus, in either case, a given volume of coal fed to the grate will be shown by a corresponding number on the indicator. It remains now to find the coeffi-

cient which will enable the engineer to translate this number into weight. This can be done only by experiment, as every grade of coal will have its own coefficient. But where the same kind of coal is always used, as is usually the case in a boiler house, the coefficient, once found, is invariable, and this is, therefore, a small inconvenience. An approximation averaging not more than 5 per cent of error is claimed for the apparatus, but this, of course, will vary according to the exactitude with which the coeffiicient is arrived at.

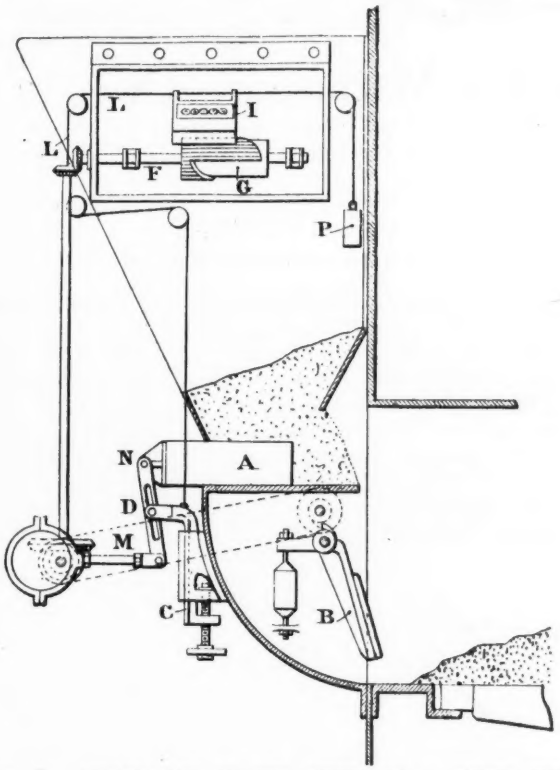


FIG. 4. APPLICATION OF THE METER TO A BOILER FED INTERMITTENTLY

A Chart for Figuring Horsepower

By W. F. Schaphorst

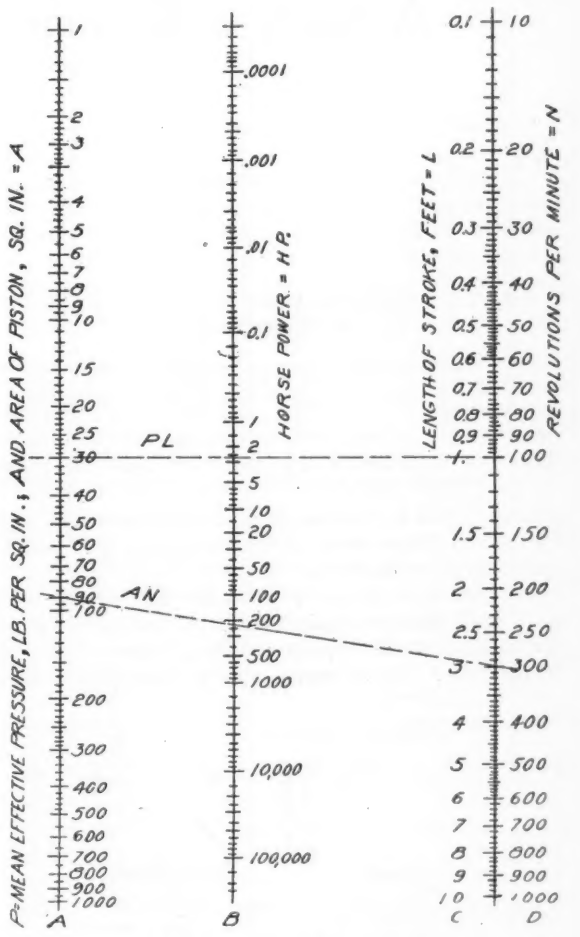
THE CHART here given solves the much used formula:

$$\text{Hp.} = \frac{\text{Plan}}{33{,}000}$$

For example, what is the horsepower of the crank end of a steam engine, the mean effective pressure being 30 lb. per sq. in., the piston area 90 sq. in., the length of stroke 1 ft., and the number of revolutions being 300 per min.?

Connect 30-in. column A with the 1-in. column C and locate the intersection with column B. Then connect the 90-in. column A with the 300-in. column D and locate the second intersection with column B. Now locate the mid-point between the intersections in column B. It is a simple matter to find the mid-point by folding a piece of marked paper, by means of a pair of dividers, by measuring with a rule, or any other easy way of bisecting a line. The mid-point in this case gives the horsepower of the crank end as being very close to 25 hp. Multiply it out longhand and you will find the exact power as given by the formula to be 24.5 hp.

The chart will therefore prove itself to be highly useful in checking over your figures, in case you are desirous of being absolutely sure of your computations. Generally it will be found close enough for most practical purposes.



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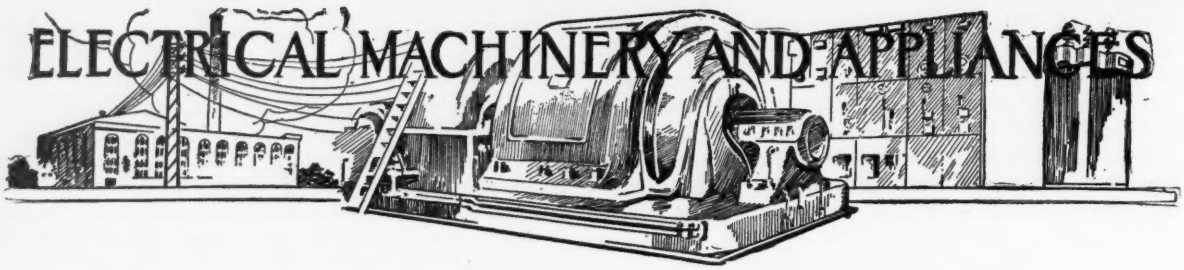
It will be noted that the range of the chart is very great, indeed—running up to over 100,000 hp., thus including every steam engine ever built. The lowest range is 1/10,000 hp., which would be a very small model engine.

National Park Bank, in a letter sent out by its foreign trade department, states that the situation abroad has become urgent by reason of extraordinary reduction in output. It makes the following statement: "Before the war, our annual exports of coal to all parts of the world amounted to something less than 20,000,000 tons; but this year, it is estimated, Europe alone will call on us for more than 40,000,000 tons, and other countries will make additional heavy demands."



A Study of Dynamo Electric Machinery---IX

ALTERNATING-CURRENT LAWS; INDUCTIVE AND CAPACITY REACTANCE; RESONANCE. BY OTTOMAR H. HENSCHEL

WHEN a conductor carries an alternating current the current density near the surface is considerably greater than that near the axis, and, as a consequence, the virtual resistance of the conductor is somewhat in excess of its actual resistance. This phenomena is called "skin effect," and is present to a greater degree in the case of high frequencies and large conductors than when lower frequencies and smaller conductors are employed.

SKIN-EFFECT FACTORS FOR VARIOUS FREQUENCIES AND SIZES OF CONDUCTORS

Wire No	0	00	000	0000	½ in.	¾ in.	1 in.
25-Cycle Factor				1.001	1.002	1.007	1.020
60- " "	1.001	1.002	1.005	1.006	1.008	1.040	1.111
133- " "	1.008	1.010	1.017	1.027	1.039	1.156	1.397

The skin-effect factor by which the ohmic resistance is to be multiplied to obtain the virtual resistance for different sizes of conductors and frequencies is as given in the table. Let us assume that a transmission line of number 00 wire and operating at a frequency of 60 cycles per second has a resistance of 75 ohms. If this line be carrying alternating current instead of direct current, the virtual resistance is not 75 ohms but 75 times 1.002 or 75.15 ohms. In a like manner, should the frequency be increased to 133 cycles, the virtual resistance would be 75 times 1.010 or 75.75 ohms; 1.002 and 1.010 are skin-effect factors for 60 and 133 cycles per second respectively, as given in the table.

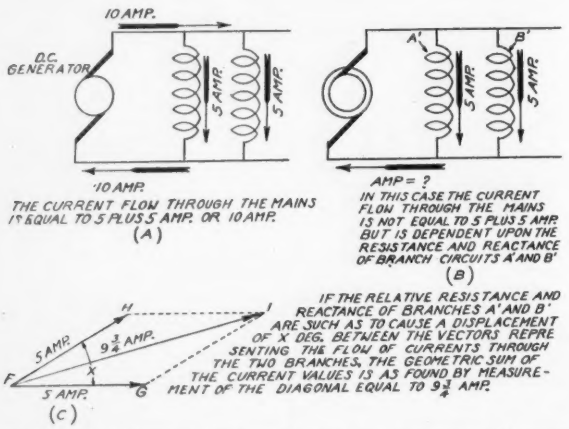

10 AMP.
D.C. GENERATOR
5 AMP.
5 AMP.
10 AMP.
THE CURRENT FLOW THROUGH THE MAINS IS EQUAL TO 5 PLUS 5 AMP. OR 10 AMP.
(A)
A'
B'
5 AMP.
5 AMP.
AMP. = ?
IN THIS CASE THE CURRENT FLOW THROUGH THE MAINS IS NOT EQUAL TO 5 PLUS 5 AMP. BUT IS DEPENDENT UPON THE RESISTANCE AND REACTANCE OF BRANCH CIRCUITS A AND B'
(B)
H
I
F
G
X
5 AMP.
9¾ AMP.
5 AMP.
IF THE RELATIVE RESISTANCE AND REACTANCE OF BRANCHES A' AND B' ARE SUCH AS TO CAUSE A DISPLACEMENT OF X DEG. BETWEEN THE VECTORS REPRESENTING THE FLOW OF CURRENTS THROUGH THE TWO BRANCHES, THE GEOMETRIC SUM OF THE CURRENT VALUES IS AS FOUND BY MEASUREMENT OF THE DIAGONAL EQUAL TO 9¾ AMP.
(C)

FIG. 57. GRAPHICAL ILLUSTRATION OF KIRCHOFF'S FIRST LAW OF ALTERNATING-CURRENT CIRCUITS

ALTERNATING-CURRENT LAWS

AS IN THE CASE of direct-current work, certain fundamental laws exist, which are presented, at this point, to enable the student to understand more readily the following discussions. From a review of Ohm's law, as applied to direct currents, we find that the current flow through any circuit containing ohmic resistance is equal to the quotient obtained by dividing the electromotive force in volts by the resistance in ohms. Where, however, inductance or capacity, or both, are involved, the actual resistance to the flow of current is in excess of

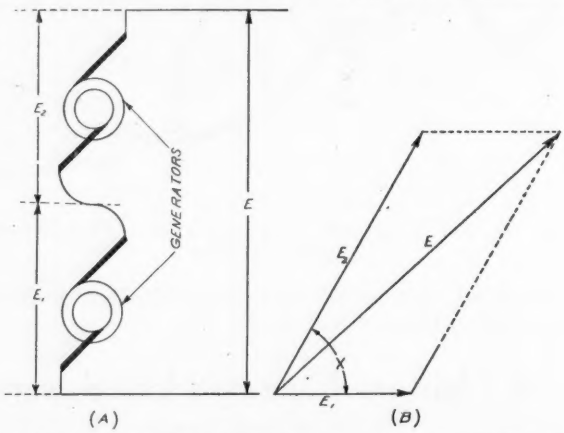


FIG. 58. WHEN TWO ALTERNATORS ARE CONNECTED IN SERIES THE TOTAL EFFECTIVE ELECTROMOTIVE FORCE IS THE VECTOR SUM OF THE EFFECTIVE ELECTROMOTIVE FORCES OF THE INDIVIDUAL ALTERNATORS

that offered by the ohmic resistance and the skin effect, unless the existing inductance and capacity are of such value as to neutralize one another. Under such conditions, a modified form of Ohm's law, generally termed "Ohm's law for alternating-current circuits" is employed. This law states that the effective current in amperes is equal to the quotient obtained by dividing the effective electromotive force in volts, by the square root of the sum of the square of the resistance in ohms and the square of the reactance, also in ohms, and may be represented by the following formula:

$$I = E \div \sqrt{R^2 + X^2}$$

I is the effective current in amperes produced by an effective electromotive force of E volts acting on a circuit of which the resistance is R ohms and the reactance, that is, the combined effect of inductance and capacity is X ohms.

Another law, that of Joule, reads that P is equal to RI^2, in which P is the power expended in watts in heating a circuit of R ohms resistance through which an effective current of I amperes flows.

Kirchoff's laws of alternating-current circuits deal primarily with the composition and resolution of electromotive forces and currents, the first of which states that "when an alternating-current circuit branches, the effective current in the main circuit is the geometric (as in the case of parallelogram of forces) or vector sum of the effective currents in the separate branches."

Shown at A, Fig. 57, is an elementary diagram of connections of a direct-current generator, delivering current to two receiving circuits connected in parallel between the mains of the machines. The current flow through the mains is at any instant equal to the sum of the currents flowing through each of the branches, so that if upon measurement, it is found that 5 amp. of current are passing through each branch, we know at once that the current flow through the mains is equal to 2 times 5 or 10 amp.

Such is, however, not the case with alternating-current circuits, for due to the presence of inductance and capacity (that is, reactance), the maximum values of the

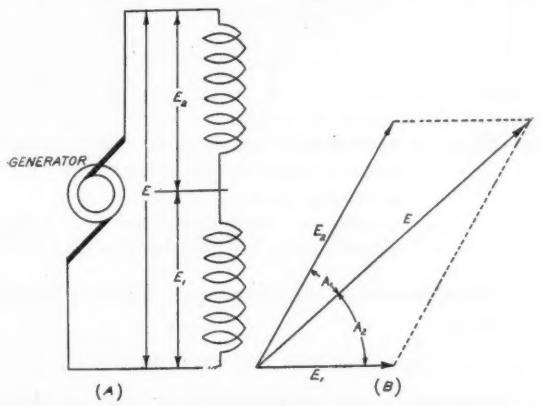


FIG. 59. E, THE ELECTROMOTIVE FORCE ACROSS THE MACHINE TERMINALS, IS EQUAL TO THE VECTOR SUM OF E_1 AND E_2

current waves will not be reached simultaneously. In other words, an angular displacement as shown at C, Fig. 57, occurs. The value of this angular displacement represented by angle X is dependent upon the value of the resistance and the reactance of each of the branch circuits.

Knowing the value of this angular displacement and the number of amperes of current flowing through each of branches A^1 and B^1, the value of the current in the main may be determined by graphical means as shown at C, Fig. 57.

Letting some unit of measurement, as for example, 1 in. represent the value of 1 amp. of current, lay off horizontal line FG 5 in. long (to represent 5 amp.). Then, at an angle of X degrees, to FG, draw FH also 5 in. in length and complete the parallelogram by drawing parallel to FG, HI, and GI parallel to FH. Diagonal FI represents the value of the current flow through the main and upon measurement is found to have a length of 9¾ in., thus indicating a flow of 9¾ amp. through the main.

KIRCHOFF'S SECOND LAW

KIRCHOFF'S SECOND LAW is of two parts and follows:

(a) When two or more sources of alternating-current supply (such as alternators or transformers) are connected in series, the total effective electromotive force is the geometric or vector sum of the effective electromotive forces of the individual alternators.

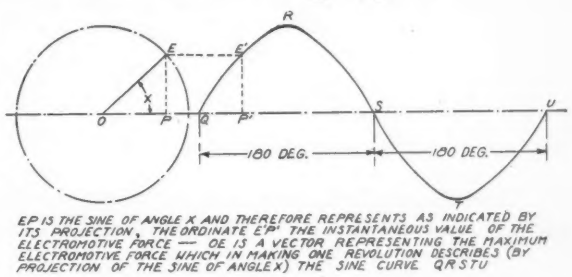

R
E
E'
X
O
P
Q
P'
S
U
180 DEG.
180 DEG.
T
EP IS THE SINE OF ANGLE X AND THEREFORE REPRESENTS AS INDICATED BY ITS PROJECTION, THE ORDINATE E'P' THE INSTANTANEOUS VALUE OF THE ELECTROMOTIVE FORCE — OE IS A VECTOR REPRESENTING THE MAXIMUM ELECTROMOTIVE FORCE WHICH IN MAKING ONE REVOLUTION DESCRIBES (BY PROJECTION OF THE SINE OF ANGLE X) THE SINE CURVE QRSTU

FIG. 60. FOR THE DEVELOPMENT OF ONE POSITIVE AND ONE NEGATIVE WAVE OE MUST MAKE ONE REVOLUTION

(b) When an alternating electromotive force, E, acts upon a number of current-consuming elements or devices connected in series, it is subdivided into parts, each of which acts upon one of the elements and the geometric or vector sum of these parts is equal to E.

As an example of case (a) we have shown in Fig. 58, two alternating-current generators connected in series. The total electromotive force across the mains is not equal to E_1 plus E_2, but is equal to the geometric or vector sum of E_1 and E_2 as indicated at B, Fig. 58; the value of angle X depends upon the positions of the armature coils in the machines relative to their respective field magnets.

The parallelogram of electromotive forces shown at B, Fig. 59, is constructed as at C, Fig. 57 and the value of E, the diagonal, is determined as in that instance.

Where an alternator supplies current to two receiving circuits connected in series the electromotive force is resolved into two components, E_1 and E_2, the values of which depend upon the relative resistance and reactance of the respective coils. As may be seen by reference to Fig. 59 the arithmetical value of E_1 plus E_2 is greater than the value of E.

Where current and electromotive force follow the path of a sine wave, that is, in the case of sinusoidal currents and voltages, and where only resistance is encountered, the current at any instant is proportional to the instantaneous value of the impressed electromotive force. By plotting the instantaneous value of such an electromotive force and current it will be seen that their respective waves pass through zero and reach their maximum values at the same instant. They are said to be in phase.

In the construction of the sine curve as exemplified in Fig. 60, it is evident that for the development of one positive and one negative wave the vector representing the maximum electromotive force must complete one

revolution and as indicated, the value of any instantaneous electromotive force is equal to the product of the value represented by the vector and the sine of the angle this makes with the horizontal. Let us assume as shown, the vector *OE* to be making an angle of *X* degrees with the horizontal; *EP* then represents the value of the instantaneous electromotive force or that represented by the ordinate $E^1 P^1$ on the curve.

When *OE* makes one complete revolution, it is said to have passed through an angle of 360 deg., but, in-

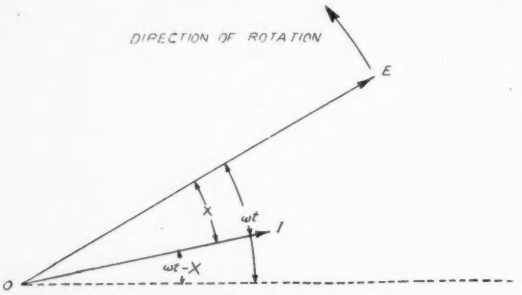


FIG. 61. THE INSTANTANEOUS CURRENT IS EQUAL TO *I* SIN *(wt-x)*

stead of employing the term of 360 deg. it is usual in electrical-engineering parlance to express such a complete revolution in radians, a radian being defined as that angle whose subtended arc has a length equal to the radius of the circle. Such an angle is equal to 57.3 deg., and as there are 360 deg. in a circle there are 2 times 3.1416 radians in a circle. If, therefore, the number of revolutions per second of vector *OE*, or the frequency, is represented by *f* and the number of seconds *OE* is in rotation by *t*, then the angle through which *OE* has passed may be designated by $2 \times 3.1416\ ft$ and as

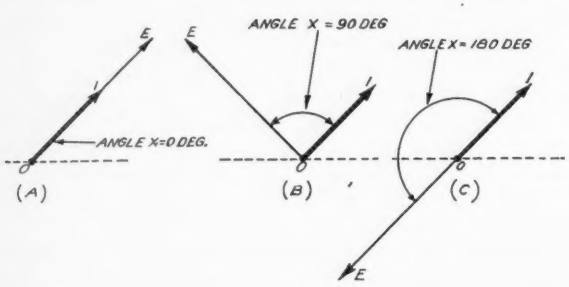


FIG. 62. (A) ELECTROMOTIVE FORCE AND CURRENT IN PHASE
(B) ELECTROMOTIVE FORCE AND CURRENT IN QUADRATURE
(C) ELECTROMOTIVE FORCE AND CURRENT IN OPPOSITION

from the above discussion the instantaneous electromotive force is equal to the product of the maximum electromotive force (represented by *OE* in this case) and the sine of the angle we find any instantaneous value of electromotive force *e* equal to $E\ max.$ sin $2 \times 3.1416\ ft$.

In this equation, as already specified, $E\ max.$ is the value of *OE*, the maximum electromotive force; *f* is the frequency in cycles per second and *t* is the time element in seconds.

That part of the foregoing equation represented by $2 \times 3.1416\ f$ may be designated by the letter *w* so that we have $O = E\ max.$ sin *wt*.

Referring to Fig. 61, we have *OE* the electromotive force vector at an angle of *wt* deg. from the horizontal with *OI* the current vector lagging behind *OE* at an angle of *X* deg. *OI* therefore is an angle of *(wt — x)* from the horizontal. From this it is, then, quite evident that the instantaneous current value *i*, is therefore equal to *I* sin *(wt — x)* where *I* is the maximum current.

When angle *x* is zero, the electromotive force and current are said to be in phase with each other, while when angle *x* is 90 deg., the electromotive force is zero when the current is at its maximum value, and vice versa. Under these conditions, they are said to be in quadrature with each other.

When angle *x* is 180 deg., the electromotive force and current are said to be in opposition; they pass through

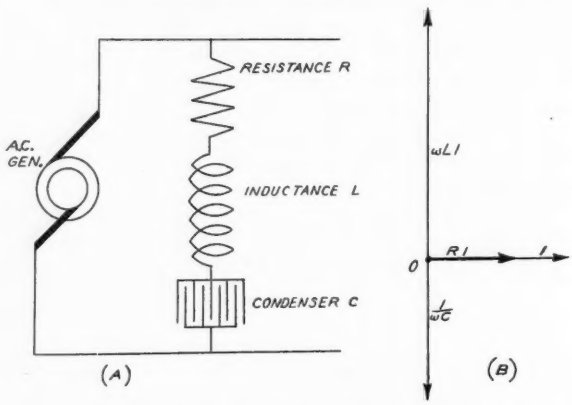


FIG. 63. (A) ELEMENTARY DIAGRAM OF CONNECTIONS OF CIRCUIT CONTAINING RESISTANCE *R*, INDUCTANCE *L* AND CAPACITY *C*
(B) GRAPHICAL REPRESENTATION OF CURRENT RELATIONS IN CIRCUIT SHOWN IN (A)

zero simultaneously, but when one is positive the other is negative.

INDUCTANCE AND CAPACITY REACTANCE

PRACTICALLY, the electromotive force of an alternating-current generator is used to overcome not only resistance but also inductance and in some instances capacity either with or without inductance depending upon the characteristics of the receiving circuit or circuits and current-consuming device or devices. Where inductance exists there is also resistance and as they are essentially different in nature and effect it is usual to consider them separately as indicated by the elementary diagram of connections shown at A, Fig. 63. Assuming the current in this circuit to be harmonic, we may represent this graphically by the vector *OI* at B, Fig. 63.

That part of the eletromotive force of an alternator employed to overcome resistance only may, as in the case of direct-current work, be expressed as the product of the current flow in amperes and the resistance in ohms or by *RI*. This is in phase with the current so may be represented by vector *RI*, B, Fig. 63.

As the electromotive force used to overcome the resistance is an alternating electromotive force so is that

used to overcome the inductance the effective value of which is $2 \times 3.1416\ f\ LI$ or as $2 \times 3.1416\ f$ is equal to w, by wLI. This is 90 deg. ahead of I in phase and as shown at B, is represented by vector wLI.

That portion of the electromotive force employed to overcome the electro-elasticity of the condenser is 90 deg. behind the current I in phase and has an effective value equal to $I \div 2 \times 3.1416\ fC$ or $I \div wC$. Graphically it is represented by vector $\frac{I}{wC}$.

As previously stated, the total electromotive force E of the alternating-current generator is used to overcome the resistance, the inductance and the capacity of the connected load. The value of this electromotive force E may readily be determined graphically by the diagram, Fig. 64; its resemblance to that shown at B, Fig. 63, is apparent.

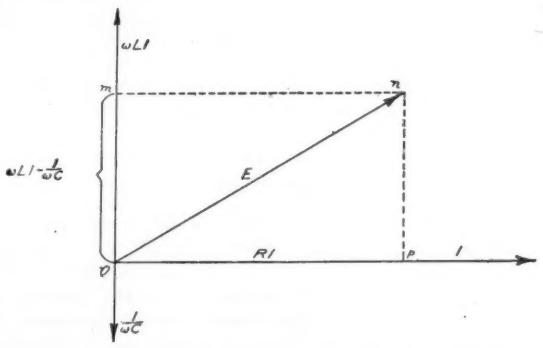


FIG. 64. GRAPHICAL MEANS OF DETERMINING ELECTROMOTIVE FORCE REQUIRED TO OVERCOME THE RESISTANCE, INDUCTANCE AND CAPACITY OF A CIRCUIT AS SHOWN AT (A) FIG. 63

The value of E is equal to the sum RI, wLI and $\frac{I}{wC}$ It is seen that wLI and $\frac{I}{wC}$ are of opposite sign so that the sum of wLI and $\frac{I}{wC}$ is in reality equal to $\left\{wLI - \frac{I}{wC}\right\}$ which is represented by the vector $\left\{wLI - \frac{I}{wC}\right\}$ found by laying off along vector wLI vector $\left\{wLI - \frac{I}{wC}\right\}$ which as may be seen is equal in length to Om or wLI minus $\frac{I}{wC}$. At the end of vector RI is erected perpendicular np equal in length to om or representing as it does the value of $\left\{wLI - \frac{I}{wC}\right\}$. In order therefore to obtain the value of vector or generator sum of RI and $\left\{wLI - \frac{I}{wC}\right\}$ it is necessary to determine the value of the diagonal, which being the hypothenuse of triangle onp is equal to the square root of the sum of the squares of op and np or,

$$on = \sqrt{op^2 + np^2}$$

E is, however, equal to on while np is equal to $\left\{wLI - \frac{I}{wC}\right\}$ and op equal to RI. We have therefore:

$$E = \sqrt{(RI)^2 + \left\{wLI - \frac{I}{wC}\right\}^2} \text{ or}$$

$$E^2 = R^2I^2 + \left\{wLI - \frac{I}{wC}\right\}^2 \text{ or,}$$

$$E^2 = I^2\left[R^2 + \left\{wL - \frac{1}{wC}\right\}^2\right]$$

By transformation and extraction of the square root of this equation we find I to have a value of E divided by $\sqrt{R^2 + \left\{wL - \frac{1}{wC}\right\}^2}$.

The factor wL and $\frac{1}{wC}$ are termed the inductance and capacity reactances and when used together as in the last formula, may be represented by the letter X so that a simplified form of the equation is $E = I\sqrt{R^2 + X^2}$

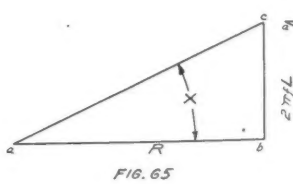


FIG. 65

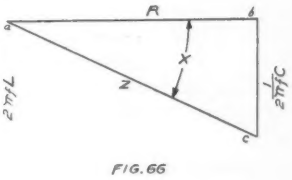


FIG. 66

FIG. 65. GRAPHICAL DETERMINATION OF IMPEDANCE OF A CIRCUIT CONTAINING ONLY RESISTANCE AND INDUCTANCE

FIG. 66. GRAPHICAL DETERMINATION OF IMPEDANCE OF A CIRCUIT CONTAINING ONLY CAPACITY AND RESISTANCE

For the sake of convenience, the factor $\sqrt{R^2 + X^2}$ is generally termed the impedance and represented by the letter Z or $E = IZ$. In alternating-current work, we therefore have I equal to $E \div Z$ or the quotient obtained by dividing the electromotive force in volts by the impedance, the practical unit of which is the ohm.

The reciprocal of impedance is termed admittance and is obtained by dividing I by the impedance in ohms.

Where the circuit under consideration contains only inductance and resistance or only capacity and resistance, the impedance may be graphically determined by means of the diagrams shown in Figs. 65 and 66. To determine the value of the impedance where only resistance and inductance exist, draw ab proportional to R, and representing the direction of current flow. At b erect perpendicular bc proportional to $2 \times 3.1416\ f\ L$ and join a and c thus giving ac representing the impedance of the circuit. Angle cab, or x is the angle of lag of the current behind the electromotive force while the cosine of angle x is the power factor.

The effect of capacity is opposite that due to inductance and as in Fig. 65 where this exists line ab is made proportional to R but bc while perpendicular to ab is drawn downward and proportional to the capacity

$$\text{or} \frac{1}{2 \times 3.1416 fc}$$

AC then as in Fig. 65 represents impedance Z and the current instead of lagging behind the electromotive force leads it by angle x.

Resonance

In Fig. 63 is shown resistance R, an inductance L and a condenser C connected in series across the main of a single-phase alternating-current generator. Let us assume that with the connections as indicated the machine is slowly set in motion although throughout this experiment, adjustment of the field rheostat is such as will provide a constant electromotive force. The inductive reactance may be represented by wL and the capacity reactance by $\frac{1}{wC}$, w in each being equal to $2 \times 3.1416\ ft$. It is therefore evident that where the speed is comparatively low the frequency f is in proportion and as a consequence the value of the inductance reactance, wL, is much less than that of the capacity reactance $\frac{1}{wC}$ and as the total net reactance is represented by $wL - \frac{1}{wC}$ this assumes a negative sign.

With increase of speed (and that of course means increase of frequency f), however, wL will increase in value while $\frac{1}{wC}$ will decrease until a point or certain critical value of frequency f is reached when $wL - \frac{1}{wC}$ becomes zero or wL is equal to $\frac{1}{wC}$. We then have

$$wL = \frac{1}{wC} \text{ or, } w^2 = \frac{1}{LC} \text{ or, } w = \frac{1}{\sqrt{LC}} \text{ or, since } w = 2 \times 3.1416\ ft.$$

$$f = \frac{1}{2 \times 3.1416\ t\sqrt{LC}}$$

The value of f termed the critical frequency is the frequency at which the inductive reactance neutralizes the capacity reactance.

Further increase of speed (but with the electromotive force still maintained constant) and therefore further increase of frequency, that is beyond the critical value, will result in an increase in inductive reactance wL and a decrease in capacity reactance $\frac{1}{wC}$ so that the net reactance but assumes a positive value.

By inserting an ammeter in the circuit shown in Fig. 63, it will be noticed that as the frequency increases the current flow increases reaching a maximum value at the critical frequency and then decreases.

This production of maximum current at the critical frequency is termed electrical resonance and may be explained by the fact that as the critical frequency inductive and capacity reactances neutralizes one another, the electromotive force produced is utilized only in overcoming the resistance of the circuit.

Effect of Resonance

Resonant conditions should as far as possible be avoided, as they are conducive to the multiplication of electromotive forces and currents; so-called "piling up" of the voltage may be disastrous to both apparatus and insulation.

Questions and Problems for Review

1. What is Joules' Law? mirchoff's Laws?
2. Explain inductance and capacity reactance. What is impedance?
3. What is resonance? What are the effects of this phenomenon?

Iron Laminations in Electric Machines

Their Functions, Manufacture and Mode of Application. By M. S. Hancock

When an alternating flux passes through an iron circuit, losses are set up in the iron which can be divided into two components, hysteresis loss and eddy current loss.

To change the flux through an iron circuit slowly from a certain density in one direction to the same density in the opposite direction, and back again to the original condition, requires a certain amount of energy. This energy is lost in the iron and is known as hysteresis loss. The hysteresis loss in an iron body of volume V carrying an alternating flux of frequency f and maximum density B is usually given as $K_1\ V\ f\ B^{1.6}$. It is independent of whether the material is laminated or not. K_1 is a constant varying with the quality of iron used and the units used for V, B; and loss.

If any material that is an electrical conductor has an alternating flux passing through it, voltages are produced in the material itself that cause currents to flow. The I^2R of these currents forms the eddy current loss. When B = maximum flux density, V = volume of material, f = frequency, K_2 = constant varying with material and units, and L = thickness of laminations (when laminated), the eddy current loss is usually given as $K_2\ V\ f^2\ L^2\ B^2$. This is when each lamination is perfectly insulated from all others. This loss depends, not on the magnetic properties of the material, but on the electrical conductivity. Different qualities of iron vary in this respect. Also it is seen that the thicker the laminations, the greater is the loss. The armature of the motor or the generator has such an alternating flux and consequently such losses.

These losses affect the heating, rating and efficiency of a motor. If the iron loss is decreased, a smaller motor may be used for a certain output at a certain temperature. Also, since the losses are less, the efficiency is higher. The iron loss is practically constant from no load to full load and so forms a constant loss to the motor user at all times the motor is running. A constant loss affects the efficiency at fractional loads much more than at full load.

Laminating the iron has no effect on the hysteresis loss. Changing the quality of iron used is the only way of reducing this loss. It is possible, however, to reduce eddy current loss by reducing the thickness of laminations, by insulating laminations more perfectly and by using iron with a higher resistance to the flow of current. Since the eddy current loss is equal to $K_2 V f^2 L^2 B^2$, if K_2V and B are constant the eddy current loss increases as the square of the frequency. To keep the eddy current loss constant the thickness of laminations should be inversely proportional to the frequency. Because of these effects thinner laminations are used for machines having a high frequency of flux in the iron than are used for those having a low or moderate frequency. Theoretically it would seem that the eddy current loss could be reduced indefinitely by reducing the thickness of laminations. Experience has shown this to be impractical past a certain point. If the lamination becomes too thin the punching tends to be drawn out of shape when the punching is large, and the burr at the edge of the punching becomes large as compared to the thickness of lamination. This results in an armature core that is not mechanically good and that again has a high eddy current loss due to the insulation between laminations being pierced by the burr.

In the case of field poles, the flux does not alternate but increases and decreases. The part of the pole face just over an armature tooth will have a higher flux density than that over a slot. This gives the same effect as an alternating flux, but in a modified degree. The steel used for the laminated parts of the motor is received at the factory from the mill in the form of large sheets, and already annealed. The annealing affects the constant K_1 and K_2, and the factory tests all shipments of such steel to see that they have the right properties.

The first operation, in the case of punchings for industrial motors, is to enamel the large sheets of steel. The sheet is run between two rolls that are kept covered with liquid enamel. This places a coating of liquid enamel on each side of the sheet. From the rolls the sheet goes onto an endless chain which carries it through an oven. While passing through this oven, the enamel is thoroughly baked on. This operation then gives large sheets of steel with insulating enamel smoothly and thoroughly baked on both sides. After enameling, the sheets are sent to the shears, where they are cut into long strips, squares or whatever form desirable for punching. From the shears the material is sent to the punch press. Here it is punched by one or more operations into the final shape of lamination wanted. If the die is made to punch the entire lamination in its final state from the plain sheet in one movement of the press, it is called a compound die. This would complete all punching on that lamination. Other type dies are sometimes used. A very ordinary type of die punches only part of the lamination, next a second die punches another part, and it may require in sequence the use of a third or fourth die to complete the lamination. For example, in punching the lamination for the stator of some small induction motors, the first die used punches the slots and the outside edge of the lamination. The second die used punches out the inside of the lamination. A third class of die which is used for punching slots, is the index die. In using this die, the material is rotated and one slot after another is punched with the same die.

With regard to the different dies, the one selected depends on the type of punching desired and the number. If a great number are wanted, the compound die is used. If a small number, the index die is used to punch the slots and other dies punch the hole for the shaft, or any other punching needed. The compound die is comparatively expensive to make and cheap to use, while the index die is cheaper to make and the cost of labor while using is higher.

In any punching operation the edge punched is always roughened slightly on one side, forming a minute burr. This burr is objectionable in that it has a tendency to cut through the enamel on the adjacent lamination, thus forming an electrical contact and increasing eddy current loss. This burr gradually increases in size as the die wears. It is kept small by good care of the dies and by not using them too long. Before the burr becomes bad the die is changed. In this way the maximum size of the burr is limited. The effect of what little burr is permitted is largely overcome by assembling the laminations in the order of their punching and with the burr on all laminations pointing in the same direction. In this way the burr on two adjacent laminations is always of about the same size and overlaps; hence it does not make a good electrical connection.

Some small punchings are bumped after leaving the punch press. They are usually punchings for fractional horsepower motors. When a punching is bumped, it is put in a press between two flat surfaces and pressure is applied between the two surfaces. This pressure is not high and is not for the purpose of flattening burrs but is to make the punchings absolutely flat so that they will assemble well.

The rotor of a motor may be assembled on the shaft with which it is to be used, or may be assembled on a duplicate shaft and then riveted to hold it together, or may be assembled on a spider. The second method is the most common in the assembly of industrial motors. In assembling, the first step is to "count" the laminations used so as to get the number to make the proper size of core. This is sometimes done by actually counting the laminations, sometimes they are weighed to get the right number and sometimes they are assembled so as to get a certain size core before tightening up, as measured by a scale. The different methods make no difference. The aim in each is to use such a number of laminations that, when tightened up, the dimensions of the core will be correct. Having "counted" the punchings, the assembler takes them in the order brought to him, which is the order of punching, and feels each punching to make sure that the burr is on the same side on all of them. Next he puts them on the shaft, duplicate shaft or spider, as the case may be. They are lined up properly by means of the keyway and by having a wedge shaped piece of metal extended up and down the slot space. Each new punching put on the shaft must have its keyway fit over the key of the shaft and have a slot to fit over the piece of metal. This lines up both slots and keyway. Heavier end plates are put on both sides of the core. The first one is put on the shaft before any of the punchings are put on, and the last after all punchings are on.

In the case of the core assembled on the shaft with which it is to be used, the core is next compressed and either pressed on a knurled shaft, in which case the press fit holds the laminations, or is put on a shaft having a shoulder turned on it and then a ring is so shrunk on the shaft as to hold the laminations solidly between the shoulder and the ring. The duplicate shaft used for assembling is threaded at the top. A nut is put on and tightened down on the end plates, thus compressing this type core. While still compressed, long rivets are passed through holes in the core and end plates and are then riveted down so as to hold the core together. The nut is then taken off and the duplicate shaft removed. In the case of a core assembled on a spider, the core is compressed and keys are driven in slots in the spider in such a way as to keep the core from expanding. The keys hold the end plate in place on the spider, thus preventing the core from loosening up. The slots are filed to remove the edges of any laminations that do not line up properly. This is to prevent the laminations from cutting the coil insulation. The final operations on the armature are pressing in the shaft, winding, connecting, painting and assembling in the stator. The punching and assembling of the poles of direct-current motors is very similar to the procedure just given for the armatures.—The Electric Journal.

Nisqually Substation, Tacoma, Wash.

SUPPLY of electric energy for the city of Tacoma, Washington, is provided for by the Nisqually Substation of the Department of Light and Water of that city. The station was designed to transform and distribute a capacity of 20,000 kw. Three-phase, 60-cycle

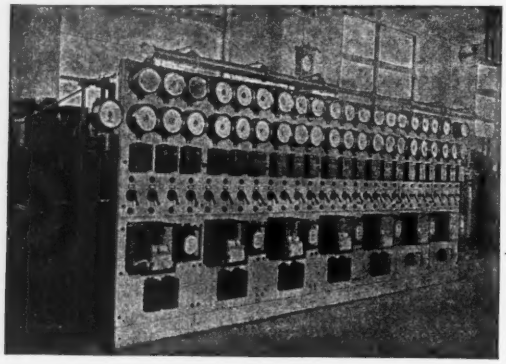


FIG. 1. NISQUALLY SEVEN-PANEL SWITCHBOARD

power is received at 50,000 v. over two transmission lines from the hydroelectric station at Legrande, 36 mi. distant. A tap is taken off the high-tension line to supply Camp Lewis and also the pumping station for the city water supply. Current is distributed at 2300 v. and at 4000 v. to the city for light and power. By agreement with the city, the private company operating therein is not allowed to furnish any light, or any power in units under 25 hp., within the city limits.

Though the station was originally designed for a capacity of 20,000 kw., it usually carries a load of 24,000 kw. or over. The station is under the direction of F. S. Morrison, chief operator, who has under him one operator and an assistant for each of the three 8-hr. shifts.

For regulating the voltage of the light and power feeders there are installed twenty-one 69-kv.a. single-phase automatic feed regulators.

The switchboard for the control of the incoming lines, outgoing feeders, arc circuits and auxiliaries in the station are built in sections and mounted separately, as shown in the accompanying illustration. The boards are of blue Vermont marble surmounted by cornice work and are equipped with usual complement of switching and measuring devices, making altogether a most attractive looking installation. Each outgoing feeder circuit is equipped with a graphic recording meter.

Standby current for the operation of the remote-controlled circuit-breakers and the pilot lamps is furnished by a 65-cell storage battery which floats on the line continuously. Current for normal operation and for charging this battery is supplied by a motor-generator installed in the basement. The battery is kept floating on the line continuously; that is, it is never discharged except in an emergency, and charged just enough to equalize the cells once every two weeks; at other times, the motor-generator carries the load and the battery floats.

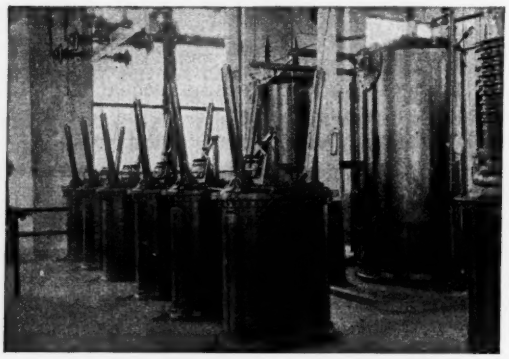


FIG. 2. OIL CIRCUIT-BREAKERS ON INCOMING LINES WITH TRANSFORMERS IN BACKGROUND

The floating voltage of the battery is from 2.10 to 2.14 v. per cell, and in order to protect the graphic meters and pilot lamps, it was necessary to insert a resistance. The resistance originally used was a grid with a standard rheostat head which protected the devices, but did not allow enough current to pass to operate the oil circuit-breakers. In order to overcome this difficulty, counter cells were installed, some of which were built up out of old battery elements. These cells reduce the voltage, but at the same time permit a sufficient flow of current to operate the breakers. There are 12 counter cells divided into three groups of four each, with taps taken off so as to permit the cutting in or out of one or more groups, as may be desired, and they are so connected that the current passes through them from positive to negative, thus continuously charging them.

Operation of the graphic meters and pilot lamps requires a continuous flow of about 7 amp. through the counter cells, which causes a rapid evaporation of the water as well as the deterioration of positive plates. To overcome this, Superintendent Morrison has adopted

the following scheme, which has worked out most successfully: A 6.6 amp. series burning incandescent lamp is connected across each group of four cells. This shunts 6 amp. away from the cells, reducing the current flowing therein to from ½ to ¾ amp., and at the same time affords the benefit of the illumination given by the lamps, which are located at certain points where it is needed. These locations are vital points and, in the event of the power going off at night, the illumination is of the greatest assistance to the station operator.

In operating one of the circuit-breakers, the current momentarily reaches a value of 7 amp., thus subjecting the lamps to an over rush of current. In order to correct this Mr. Morrison expects to add three more cells, making a total of 15, and divide them into three groups of five each, and install a short piece of resistance wire in series with each lamp so as to hold down the current to 6 amp. A snap switch is installed on each lamp so that when the battery is getting its equalizing charge the lamp can be cut out, causing the counter cells to build up to their highest voltage at the time when it is most needed.

Elevator Hazards*

SAFETY DEVICES NECESSARY FOR PROTECTION. IMPORTANCE OF FREQUENT INSPECTION. BY DANA WEBSTER

ABOUT the middle of the Nineteenth Century, platforms or cable hoisted elevators were first installed in New York and Boston, but were not provided with any kind of safety devices and, strange to say, a few elevators without safety devices exist at the present time.

A few years later, elevators were equipped with safety devices of such type that it was necessary for the hoist cable to break before the safety could actuate. There are a great many of this type of safety in use today, but with the introduction of high-speed elevators, which were required to meet the demands of the public, quite naturally it necessitated a much better type of safety apparatus and a multiplicity of cables.

Accidents could and did occur from over-speeding elevators, caused by disarrangements of the controlling apparatus, and it became necessary to provide safety devices that would actuate should the elevator speed increase beyond a predetermined number of feet per minute.

The most essential elements of safety are the prevention of excessive speed from any cause, the overrunning of the limits of travel at top and bottom, safe protection at the landing entrances to the elevator, and a regular examination of the cables and all parts of the elevator equipments.

CAR SAFETY DEVICE

THE EARLY type of the safety device was designed to stop the car instantaneously. They served the purpose satisfactorily for slow speed, but were not adequate for the higher speed of 400 to 700 ft. per minute. It, therefore, became necessary to provide a safety device that would stop the car with an easy and gradual stop. This is accomplished by the friction clamp safety which is actuated by a safety speed governor, usually set to trip at 40 per cent above regular speed. This governor will act should the hoist cable break, allowing the car to drop, or should the car over-speed from some defect in the machinery after the governor trips and the car has dropped far enough to take up the clearance of the safety jaws. The jaws are forced hard against the guide rail (like a vise), and the car will continue to slide until the friction is enough to stop the car entirely. The distance the car will slide after the safety takes hold, depends upon the load; but the farther the car slides, the tighter the safety grips the rail. Usually a car will drop about six feet after the governor trips and clamps the governor cable.

OVER-RUNNING OF LIMIT STOP

THE MACHINE of all power operated elevators should be equipped with automatic limit stops; that is, a device that will stop the elevator at the top and bottom limit of travel, regardless of the operator.

On drum machines, the automatic limit stop should be built with and made a part of the machine.

On hydraulic elevators, the automatic limit stop should consist of a cutoff valve, either in the to-and-from pipe, or in both the supply and discharge pipe.

On traction type of elevators, the automatic limit stops must be located in the hoistway, and the power cut off by the travel of the car. As there is more or less slippage of the hoist cables on the drive sheave, a machine automatic would not be dependable. In addition to automatic limit stops on electric elevators, there are hoistway limit switches located so that should the car travel a certain distance by the automatic limit stop, the car would open a switch, thus cutting off the power and stopping the machine.

SAFE PROTECTION AT LANDINGS

THE EARLY types of passenger elevators—and in fact most elevators up to the present time—are provided with landing doors equipped with a catch located on the inside so that the door can only be opened by the operator. The operator, however, in order to make speed—and the public is partly to blame for this—starts the elevator before the door is closed, and quite often the door would not fully close and latch, thus providing a very dangerous condition. Many persons have opened the door when finding it ajar and, looking in the hoistway, have either fallen or have been knocked down the hoistway by the car and severely injured or killed. I might say right here that statistics show that 85 to 90 per cent of all elevator accidents occur at the landing doors. Therefore, it became necessary to provide the landing doors with a locking device that would prevent the doors from being opened, unless the car was at the landing; also to prevent the car from being removed away from the landing until the landing doors were closed. This is termed the interlocking device, or inter-

*Abstract of paper read before the Eighth Annual Safety Congress of the National Safety Council.

locks for landing doors. At the present time only a small percentage of elevators are equipped with this device, although they are becoming more and more generally used.

Cables

The cables are the most essential parts of the elevator equipment, and their number and size should be equal to the load with a good factor of safety. The sheave should be of ample size and placed in alinement to prevent chafing of the cables on the sides.

Inspection

Every elevator should be regularly inspected by a competent elevator inspector, who should inspect all the different safety devices, machinery, cables, etc.; in fact. everything pertaining to the elevator. The landing doors should be tried to determine whether they can be opened from the outside. The car safety device should be tested to be sure that it would actuate and hold the car from falling, should the cable break. The automatic limit stops should be tested so as to be sure the car will not over-run and strike the overhead beams or bumpers. The slack cable device should be tested to be positive the power would be cut off, should the cables slacken. The brake should be examined to be sure there is no slippage. The cables should be examined very carefully for defects, as there is no part of an elevator that requires the exercise of more good judgment than the examination of the cables. After an inspection has been made, the owner should proceed immediately to install safeguards and remedy any defects reported.

The elevator should be oiled and greased regularly by the engineer and looked over carefully for any defects, as often the engineer will discover some little defect which if fixed immediately may avoid a serious accident.

All glass, except the electric light bulbs, should be eliminated from passenger elevators.

Industrial Safety---V

Fire Protection in Relation to Safety.* By Sidney J. Williams

INJURIES from fire are less frequent than other accidental injuries, but are generally serious and often fatal. The greatest loss of life is not in spectacular fires where dozens or hundreds of persons are killed, but in the aggregate of thousands of small fires.

The best way to prevent deaths or injuries from fire is to prevent the fire. It is also necessary to stop a possible fire from spreading rapidly, by means of proper building construction and cutoffs; and to provide for extinguishing it while it is small. Finally, in case these should fail, proper exits are essential, and fire alarms and drills to make sure that all occupants will escape.

Fire Prevention

All electrical equipment should be installed in accordance with the National Electrical (Fire) Code and the National Electrical Safety Code, and should be carefully maintained. The following are common causes of electrical fires: Switches with poor contact point, or switches exposed to metal contact; fuses too large for the circuit, or copper wire carelessly inserted in place of a fuse; motors and generators exposed to moisture, dust, etc.; portable and pendant lamp cords with defective insulation, or in contact with nails or other metal.

Large quantities of gasoline, fuel oil, etc., should be stored in underground tanks or tanks adequately protected by retaining walls, located, if possible, away from other buildings. Local supplies of gasoline, benzine, or similar substances should be kept in safety cans which will not leak when inverted. For cleaning metal parts, such as bearings and governors, kerosene is recommended rather than gasoline. Small dipping tanks in which inflammable liquids are used, as for tempering or painting, should be equipped with tightly fitting covers which, in case of fire, will close automatically through the action of fusible links.

Cracks in chimneys, and loose joints or rust holes in smoke pipes, cause many fires. Woodwork near furnaces, stoves, or smoke pipes should be protected either by covering the heating apparatus or pipe or by interposing a metal or asbestos sheet placed about 3 in. from the wall. Any woodwork which gets uncomfortably hot to the touch should be so protected. Wooden floors below heating apparatus should be protected by a layer of hollow tile or by a zinc plate, depending on the amount of heat.

Fires frequently result from overheated bearings, from shafting out of alinement, or from lack of lubrication. Bearings should be frequently inspected to see that they are not unduly heated and are kept well lubricated.

Accumulations of combustible refuse, such as oil-soaked or paint-covered clothing, rags and waste, are dangerous. Metal containers or waste cans should be provided for such material. Although clean waste is much less hazardous than oily and dirty waste, it should be kept in metal or metal-lined bins, provided with close-fitting covers. Employes should be required to clean up all waste material daily and deposit in the proper containers. The waste can should be emptied each day and should not be allowed to stand over night.

Ashes from stoves, furnaces and boilers should never be stored in wooden bins or near combustible material. Metal storage cans and bins should be provided, or ashes put on cement floor or on ground outside of building away from any woodwork. No rags, papers, or other inflammable refuse should be mixed with ashes.

Some of the worst fires on record have been caused by lighted matches or cigarette or cigar stubs being thrown into waste baskets or other inflammable material. There is a growing tendency to prohibit smoking in all departments of manufacturing plants where there is any fire risk. Smoking should certainly be prohibited in woodworking shops, textile mills, oil storehouses, pattern storage rooms, and rooms where inflammable liquids such as ether, gasoline, naphtha, benzine and alcohol are used

*From lecture delivered before Schools for Safety Engineers.

Preventing the Spread of Fire

Fire follows a draft. The burning gases given off by a hot fire will ignite other material 20 to 50 ft. away. Fires spread rapidly through open stairways and elevator shafts and other vertical openings. Such shafts should, therefore, be completely enclosed, even if the stair and the floor construction are incombustible. The enclosures should preferably be of brick, concrete, tile, or solid plaster on metal lath; but even a wooden partition will sometimes stop a fire by stopping the draft.

Fire Extinguishment

A complete automatic sprinkler system, combined with standpipes and yard hydrants, furnishes the best fire protection. Sprinkler heads should be watched for corrosion and must be kept free from paint. Fire hose should not be used for ordinary purposes; it should, however, be tested at least twice a year. After being used, it should always be thoroughly drained and dried to prevent deterioration.

Hand extinguishers are valuable for putting out small fires, even where sprinklers and hose are at hand.

Soda acid extinguishers contain a solution of about 1½ lb. bichloride of soda to 2½ gal. water, and also an inner container of four ounces of sulphuric acid. The 2½-gal. size is recommended for convenience in handling. These extinguishers must be recharged at least once a year. If not in heated buildings, they must be protected from freezing during winter months. Cabinets (felt or asbestos lined), heated by a small electric light, will provide adequate protection. Salt should not be used in the water because it may corrode the sides of the extinguisher so that it will burst when discharged.

Carbon tetrachloride extinguishers are effective for electric fires. This fluid is a non-conductor of electricity and does not injure electrical apparatus, leather, or fabrics. It does not deteriorate with age and will withstand freezing in ordinary northern climates. Test the extinguishers about twice a year, as follows: (a) empty by pumping contents into a pail; (b) work pump vigorously; (c) replace liquid and add enough to fill tank.

Foam extinguishers employ a solution of (a) aluminum sulphate and (b) sodium bicarbonate and licorice root, and are effective on oil and other liquid fires. The foam consists of numerous small bubbles, filled with carbonic acid gas, which flow over the surface of the burning oil and smother the fire.

Steam is valuable for extinguishing fires in dipping tanks, dry kilns, chip bins, and similar locations.

Sand is sometimes used for extinguishing fire in inflammable liquids, and also on electrical apparatus, although it is not so effective as the foam and carbon tetrachloride extinguishers.

Sawdust and soda is a valuable extinguishing agent for inflammable liquid fires and has the advantage of low cost. The mixture is kept ready in pails and is thrown on the fire with a scoop.

Powder tubes and hand-grenades are of practically no value in fire-fighting and should never be used.

Water barrels with close-fitting covers and fire pails are often provided at convenient locations in rooms where there is a considerable fire hazard, instead of or in addition to chemical extinguishers. They should be painted red, with the word "Fire" on the side, in white letters. These pails must not be used for any other purpose.

Salt is commonly used to reduce the freezing point of water. It is, however, not so satisfactory as calcium chloride, which, in proper proportion, will reduce the freezing point of water to about 40 deg. below zero. Where this is used, wooden tanks must be pitched on the inside to withstand the penetrating effect. Steel tanks are therefore preferred where there is danger of freezing Calcium chloride and salt cannot be used in soda-acid extinguishers.

Fire extinguishers should be placed in prominent locations, where they can easily be seen, and always kept easily accessible. Mark the location of extinguishers and fire hose by a red line on columns or floor and by red lights at night. Regular periodical inspection (each week) should be made of all fire-fighting equipment. A competent man should be assigned to this duty and should keep a record of his findings on a blank provided for that purpose.

The best of equipment may be only 25 per cent efficient in the hands of men who do not know how to use it. A man, with one or two alternates, should be assigned to each piece of hand apparatus and should receive both instruction and practice in its use. Build a fire outdoors, on a quiet day, and let the men practice putting it out.

Exits, Fire Alarms and Drills

The best exits are enclosed stairways and horizontal exits; the latter term includes doors through fire walls, and bridges or balconies to other buildings or sections.

Most outside fire escapes—especially vertical ladders—are poor makeshifts and would be of little use in an emergency. Outside stairs or fire escapes should be not steeper than 45 deg., substantially constructed, well railed, extended to the ground, and protected by wired glass windows. A fire escape which employes are afraid to use should not be counted as an exit.

All exits must be kept in good condition, free from snow and ice, and accessible at all times.

In buildings which are high or have many occupants, fire alarms and drills are necessary to notify employes and insure their orderly exit in case of fire. Alarms also serve to summon members of the private fire brigade. Electric alarms may be of either the open or the closed circuit type; the latter is the more reliable. In small plants where the hazard does not justify the cost of an electro-mechanical alarm system, mechanical gongs operated by pulling a wire or chain are sometimes used; these require very careful inspection and maintenance.

Exit drills must be conducted seriously and under rigid discipline. A permanent organization is desirable for handling employes during exit drills or fire. This should consist of a chief with assistants, room captains, stairway guards, searchers, and inspectors.

The shortage of gasoline during the war has brought about considerable use of electric vehicles in the Italian cities, especially for heavy trucking. Although with normal conditions gasoline will not continue its present price of a dollar a gallon, it will always be high in Italy, and electricity low. The cities of the Po valley are all level and the Italian roads are uniformly good.—Scientific American.

Pipe Line Transmission of Crude Oil.

(Continued from Page 1045)

This question of finding a liquid which would not mix with the water and which was just heavy enough to give displacements of the desired magnitude, was only one of many that had to be solved in adapting the differential gage to trunk-line measurements. Another difficulty encountered was due to the fact that crude oil under pressure almost always contains some free air or gas. If bubbles of this should get into the connecting lines of the differential gage they would cause an unbalanced condition which might introduce serious errors. To avoid this danger it was necessary to tap the connections into the bottom of the pipe.

Still another feature which required special attention was the constant fluctuation in pressure always found in a line through which liquids are being forced with a reciprocating pump. If no provision against this fluctuation had been made, the bromoform in the U tube

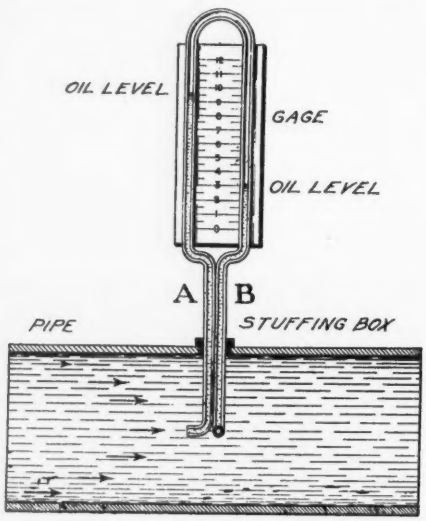


FIG. 9. PITOT TUBE USED IN OIL FLOW INVESTIGATIONS

would have jumped about to such an extent that accurate measurements would have been impossible; so it was necessary to use a differential tube of unusually large size, containing a large quantity of bromoform, the inertia of which would resist sudden movement, and also to connect the gage to the main line with very small pipes, in which friction would tend to damp out oscillating flow.

These and other refinements were perfected only by repeated trials. The form in which the apparatus was finally set up for testing purposes is illustrated in Figs. 5 and 6. From these photos it will be noted that the differential gage actually used was far more complicated than the simple one described in connection with the gravity tests.

After everything had been brought to a point where a successful gage had been developed, there remained the work of taking a great number of observations with different kinds of oils flowing at different temperatures and velocities. Along with these pressure loss measurements, careful observations of the temperature at different points in the pipe were taken, and representative samples of the flowing oil were drawn off, to be later examined in a laboratory for gravity and viscosity.

All this work of building a testing apparatus that would give satisfactory results, and then of obtaining the great mass of experimental data required the entire time of several experienced men for many months; but the net result was a set of flow curves for 8, 10 and 12-in. pipes that has proved of great value in solving pipe-line problems.

Mixing of Oils During Transportation

Flow determination is not the only difficulty encountered in pipe-line transportation. The unavoidable mixing of different grades of oil in the line has called for an almost equal amount of study. As was previously stated, there are wide variations in the flow characteristics of California oils. Refining characteristics vary fully as much. Often oils from adjoining wells on the same property, but producing from oil sands at different depths, require entirely different treatments, and yield varying products. To minimize refinery losses and difficulties by delivering the various oils with as little contamination as possible is, therefore, one of the problems of pipe line management.

Whenever one kind of oil is pumped behind another kind through a pipe line, a considerable amount of mixing between the two is bound to take place. The principal cause of such mixing lies in the fact that when any oil flows through a pipe, its different particles travel at different rates. Those at the center move at the maximum speed, while those near the walls of the pipe move much more slowly. Consequently, whenever an oil, B, is pumped into a pipe line behind another oil, A, the central particles of B will immediately start to nose their way into the oil ahead; and this process of contamination will continue throughout the entire length of line through which the two oils are pumped. The difference between the center and outside speeds of any flowing oil, and consequently its tendency toward contamination with any other oil which it may be following, depends upon the amount of turbulence with which it is flowing.

If the average rate is below the critical velocity, so that the flow is straight line in character, the speed near the walls may be less than ⅓ that at the center; while, if the average velocity is high and the viscosity low, so that considerable turbulence exists, the outside speed will probably be at least 90 per cent of that at the center. Figure 9 illustrates the instrument that is used for measuring the actual velocities in different parts of a pipe. The impact of the flowing stream against the opening in tube A, which faces directly against the stream, causes the oil in tube A to rise higher than in tube B, the opening in which is at right angles to the stream and hence subject only to the static pressure in the line. The difference in these heights is a measure of the velocity of the oil flowing through the pipe. The stuffing box is provided to permit moving the tubes up and down, and thus to secure measurements of the velocity from the top to the bottom of the pipe, without letting any oil leak out of the line, which may be under high pressure.

Figure 10 shows a record of two actual tests made

with this instrument, selected at random from a great many that have been obtained at various times. Curve X is for a 15 deg. Baumé oil at 102 deg. F., flowing about 475 bbl. per hour through an 8-in. pipe. This rate is only a little above the critical velocity; a theoretical curve assuming no turbulence is plotted as X′ for comparison. Curve Y is for a lighter oil (19.7 deg. Baumé), flowing at about the same temperature (99 deg.) but at a much higher speed (1220 bbl. per hr.). Curve Y is fairly representative of actual operating conditions in a trunk line. It will be noted that for this case the speed near the walls is approximately nine-tenths that at the center. It might be expected, therefore, that by the time particles at the center had moved 100 mi., those near the walls would have traveled only 90, and hence that if this kind of oil were following another kind through a pipe-line, the result would be a varying mixture of the two kinds all the way from the 90 to the 100-mi. post. If the line were 200 mi. long, the mixture would still be expected to cover 1/10 the total length, or 20 mi.; that is, the amount of mixture between any two kinds of oil will be in direct proportion to the size and length of the line through which they are pumped, as well as to the relative speeds of the particles near the walls and at the center of pipe.

Practically there are always a number of influences at work, some tending to increase and some to suppress the amount of mixing which might be expected from any observed velocity distribution. One of the most important of these is turbulence. For example, assume than an oil B is following oil A through a pipe line and

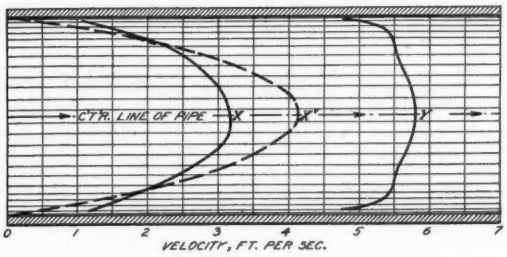


FIG. 10. VARIATION OF VELOCITY OF OIL FLOW ACROSS DIAMETER OF PIPE

that the speed at which they are moving causes turbulence in, say, the B oil. Then, as this oil tends to push its way into the oil ahead, turbulence will shunt its fast-moving central particles off into the slower-moving mass of A oil near the walls, thus preventing the nose of B from getting as far ahead as the velocity distribution would indicate. The same thing would result even if turbulence were mainly confined to the A oil, and the velocity distribution in the B oil were as in X, Fig. 10. For in this case the slower moving, but turbulent particles of A oil would be constantly projected into the fast-moving central core of B oil, thus reducing its average velocity and preventing it from getting so far ahead.

The force of gravity exerts another influence which tends to reduce the mixing below that computed from velocity differences. If, for instance, a heavy oil is following a light, as the fast-moving central portions of the heavy oil nose their way into the light oil they sink into the slower-moving portion near the bottom. On the other hand, if a light oil is behind, it will rise to the top as it works its way into the heavy oil ahead, and thus in the same way lose some of its high central velocity. The result is the same in either case—the nose of the oil behind will not get so far ahead as theory would indicate.

Hence, in order to secure data on the amount of contamination which actually takes place under practical working conditions, it has been found necessary to supplement the Pitot tube tests with actual observations of mixing in a working pipe-line through which an oil B was being pumped behind another oil A of widely different gravity; in making such tests samples of the flowing oil were drawn from the line at frequent intervals. The observed gravity of these samples was considered a sufficiently accurate criterion to determine the pres-

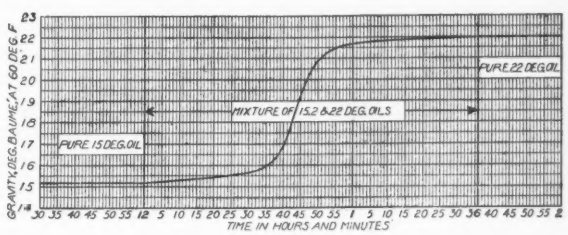


FIG. 11. THEORETICAL MIXTURE OF TWO KINDS OF OIL

ence of any mixture. By noting the time at which the first traces of oil B appeared, and again the time at which the last trace of A disappeared and knowing the average rate at which the oils were being pumped, a practical measure of the amount of mixing was obtained.

Figure 11 shows the results obtained from a typical one of many such tests that have been made. It will be noted that from the first time the presence of light oil was clearly indicated until the last of the heavy had disappeared, 1 hr. and 36 min. elapsed. As the oil was traveling at the rate of 1000 bbl. per hour, this would indicate about 1600 bbl. of mixed oil. At the time this test was made, this oil junction had traveled through about 58.7 mi. of 8-in. line—which had a total content of 19,200 bbl. Dividing the mixture by the total content, the total contamination amounts to about 8.3 per cent of the contents of the line.

If continuous flow through pipes were all that takes place when oil is pumped through a trunk line, curves similar to Fig. 11 would make it possible to estimate, with reasonable assurance of accuracy, the amount of contamination which would take place whenever any given oil followed another oil through a certain length of line; but as the oil has to be given a fresh store of pressure and heat at the pumping stations which are operated at 14 and 15-mi. intervals all along the line, this simple condition does not hold. It is impossible to keep the pumps at any station running always at exactly the same speed as the pumps at the next station up or down the line; consequently, each line must be connected, at each station, into a so-called "equalizing tank." If the pump at No. 1 line at station A is running a little faster than the corresponding pump at station B, the excess oil pumped at station A will go into station B's equalizing tank. On the other hand, if the pump at station B is running the faster, it will not get

enough oil from A and will withdraw some from its equalizing tank.

If just one kind of oil were being pumped continuously, this would not introduce any complications, for the equalizing tanks could be kept partially full of that kind of oil, and no contamination would result from pumping either into or out of those tanks. If, for example, a light oil is being pumped behind a heavy, stations A and B are both connected into their heavy oil equalizing tanks, and operating conditions are as described in the second case above; i. e., station B is running faster and withdrawing some oil from its equalizing tank. When the light oil begins to arrive at station B, the operator will be waiting to switch from his heavy to his light oil equalizing tank. Considerable time, however, is required to take the gravity of enough samples to make sure that the proper point to "cut" between the two oils has arrived and then to carry out the actual change in connections. During all this time, heavy oil is being drawn from the equalizing tank and mixed into any light oil that may be going by. This makes the line of demarcation between light and heavy beyond station B much less distinct than is the case when contamination at the junction is due only to flow through the pipe; and, as a result, the operator at station C will find it considerably more difficult to determine when to "switch" tanks. This complication may be passed on

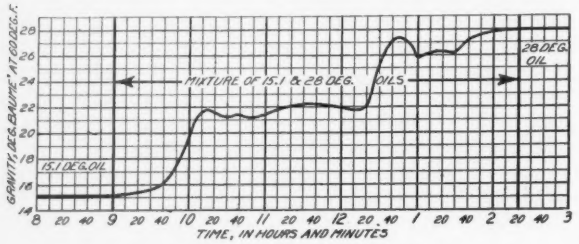


FIG. 12. ACTUAL MIXTURE OF OILS IN PIPE LINE

cumulatively all the way up the line, so that when the end is reached, considerably more contamination is found than could have been caused by continuous flow through the line. In Fig. 12, which shows the results of a test made at the receiving end of one of the Standard Oil Co.'s Bakersfield trunk lines, the effect of this condition is apparent.

The rate of pumping when the test described in Fig. 12 was made was 1256 bbl. an hour. As mixed oil was passing the point of observation from 9:00 a. m. to 2:20 p. m., the total quantity contaminated amounted to almost 7000 bbl. When it is remembered that mixtures of this order of magnitude may take place whenever two different kinds of oils are pumped successively through either of the Standard Oil Co.'s Bakersfield-Richmond trunk lines, it is clear that the question of contamination demands very serious consideration in the operation of these lines. In order to reduce to a minimum the number of times that this unavoidable mixing takes place, the field oil is segregated into groups. Oils whose refining characteristics are somewhat alike are put together and held in storage until a large quantity (never less than 100,000 bbl.) is available for shipment. The larger these batches are, the less frequent will be the occurrence of the 5000 or 10,000-bbl. mixtures which must lie between them at the delivery end of the line.

A further saving is also made by arranging the batches so that the resulting mixture will offer the least difficulty to the refining department. In this connection, it should be pointed out that the question of just when to "cut" an incoming stream of oil at the receiving end of the trunk line from, say a heavy to a light oil storage tank, is purely arbitrary. If there happens to be no great difference between the refining characteristics of the two successive oil, the "cut" is made at about the middle of the contaminated portion—say at 1:45 p. m. in Fig. 11; but if, for instance, a light oil which is to be used for special purposes is being pumped behind a heavy oil which contains certain characteristics that are harmful to the light oil, the cut cannot be made until practically the last trace of heavy oil has disappeared—say at 2:10 p. m. in Fig. 12. Under these conditions, all the light oil contained in the mixture delivered between 9:00 a. m. and 2:10 p. m. must be routed into the heavy oil tank.

Occasionally when such harmful contamination between two successive batches would be mutual—for example, when the presence of any of the light oil which might be behind would be as harmful to the heavy oil ahead as was the heavy oil to the light in the case above—a so-called "buffer" batch is placed between them. This generally amounts to about 5000 bbl. and its identity is completely lost in the trip through the line. If, for instance, it is desired to isolate completely a batch of 22-deg. oil from a batch of 25-deg. oil which it is following, a buffer batch of 5000 bbl. of 15-deg. oil is run in between them. No 15-deg. oil will appear at the receiving end of the line. As the end of the 25-deg. stream comes along the gravity may drop to, say 20 deg., but before it can get any nearer to the 15 deg. which would be expected from the presence of the buffer, the influence of the 22-deg. oil behind is felt, and gravities begin to rise again. The stream is cut at this point, and thus little or none of the 22-deg. oil gets into the 25-deg. tank, or vice versa.

There is still another feature that must always be considered in planning the sequence of batches through a line. It will be remembered that heavy oil must be heated to reduce its viscosity, and thus its resistance to flow. On the other hand, light oil is pumped practically cold, in order to minimize losses of its lighter products. It is a matter of common knowledge that when any steel structure, as a pipe line, becomes heated it expands. If it should be suddenly cooled pumping cold oil through it, serious contraction strains would be set up. These strains would tend to pull the pipe out of the threads which secure it to valves and couplings, and if they did not succeed in actually rupturing the line they would at least cause leaks at various points. For this reason great care must be exercised to route the successive batches through the line in such a way that sudden changes in temperature cannot take place.

Numerous tests and experiments are still being carried out on the various pipe-line problems that remain to be solved, in the transportation of California petroleum through pipe lines.

WALL STREET JOURNAL states that from present indications it would appear that within the next few months use of fuel oil for generation of steam will have been introduced into New York City.

The Use of Raw Tars for Diesel Engines

THEIR CHEMICAL AND PHYSICAL PROPERTIES AND REQUIRED CHARACTERISTICS. BY HAROLD MOORE

WE may summarize our knowledge of the chemical and physical properties of tar oils, and our practical experience of their behavior in Diesel engines by the following remarks:

1. The temperatures of spontaneous ignition of tar oils are much higher than those of petroleum oils. This results in ignition troubles when employing engines of standard design.

2. Tar oils are liable to form precipitates under the action of heat and compressed air. This may result in obstruction of the atomizing devices.

3. Tar oils are richer in carbon and lower in hydrogen content than petroleum oils, and they are therefore more liable to precipitate carbon on the walls of the combustion space if not burned under entirely favorable conditions. The main effect of this property of these oils is an increased wear on the exhaust valve face and seat.

The ignition difficulties with tar oils have been overcome by the employment of a variety of devices, of which the pilot ignition system, which provides for the introduction of a small charge of a petroleum or shale oil into the cylinder prior to the main fuel charge, has been the most generally utilized. Obstruction of the normal atomizing devices has become less frequent since greater attention has been given to the analyses of the tar oils, and this trouble has been overcome in several instances by the use of atomizers of special design. The increased wear of exhaust valves when employing tar oil is not very great, and only necessitates more frequent attention to this part.

Raw tars, when used as fuels for internal-combustion engines, possess to a greater or less extent all the defects of tar oils, and in addition certain defects peculiar to themselves. There is also much wider variation in the physical and chemical properties of the different tars than the usual limits of variation observed in the analysis of tar oils. This latter fact necessitates the continual and most detailed analysis of raw tars, not only tar from each new source requiring analysis, but each new delivery.

Raw tars generally possess spontaneous ignition temperatures about the same or slightly lower than those of tar oils, and they present the same ignition problems. This difficulty has in many cases been overcome by adopting the pilot ignition system and using a petroleum oil for ignition purposes. Some large Diesel-engine installations are said to have worked satisfactorily with raw tars, using a small pilot charge of the tar itself injected into the cylinder considerably in advance of the normal timing. The use of petroleum for starting purposes, which is a common practice when burning tar oils, presents greater difficulties when employing raw tars as main fuel, as deposits are formed by the addition of petroleum to raw tar, and these are greater in quantity and more viscous than the deposits which are formed by tar oil-petroleum mixtures. These deposits interfere with the working of the fuel-pump valves. Specially chosen tars of low free carbon content do not so readily cause obstruction of the atomizing devices as do certain tar oils. Whereas tar oils usually either keep clean or else readily cause obstruction, the tars more usually cause slight obstruction. It is, however, preferable to employ special atomizing devices for use with raw tars. The deposits formed in atomizers when running on raw tar are probably caused by the accumulation of free carbon.

A trouble frequently encountered when burning raw tars or other pitch or asphalt containing fuels is the formation of gummy deposits on the fuel valve stem, which is due to the partial distillation of fuel which has crept up the fuel valve. This may readily interfere with the working of the valve. It is a trouble seldom encountered when burning tar oils. It can be surmounted by the employment of devices for preventing the creeping of fuel up the valve stem.

The third trouble mentioned as being experienced in burning tar oil is the extra wear on the exhaust valve, caused by precipitation of carbon when the conditions of combustion are not satisfactory. The same trouble is occasionally encountered when burning petroleum under unfavorable conditions.

The wear on the exhaust valve is much more pronounced when burning raw tar than with petroleum oils or tar oils. Whereas with the latter fuel it is only necessary to prevent the precipitation of carbon, with raw tars precipitated carbon is already present in the form of the so-called "free carbon," and for satisfactory running it is essential to burn this free carbon during the cycle before the opening of the exhaust valve. On account of the particles of free carbon burning less rapidly than the remainder of the fuel there is considerable danger, when burning raw tars, of the exhaust valve opening before the combustion of the free carbon particles is complete. If incomplete combustion takes place, glowing particles are trapped between the valve face and the seat, which results in pitting of the valve face, and this, if allowed to become pronounced, will cause loss of compression and subsequent starting troubles. Seizure of the exhaust valve stem is also likely to occur. Increase of compression causes higher temperature in the combustion space and therefore accelerates combustion. High engine speeds afford less time for complete combustion, and therefore cleaner running is experienced at slower speeds.

The majority of petroleum and tar oils contain less than 0.02 per cent of ash, and it is rarely, therefore, that ash troubles are noticeable on engines employing these fuels. As tars contain much greater quantities of ash, and in many cases cannot be employed on account of ash trouble, a much greater wear on the piston rings and liner may be expected when engines are running on tars than when employing tar oils.

As raw tars are frequently high in viscosity, there is often difficulty in freeing them from water, which does not readily separate out. The presence of water causes misfiring and irregular running.

Properties of Tars

Both the yield and the chemical constitution and physical properties of tars depend mainly upon the following factors:

1. The nature of the coal from which the tar originates.
2. The rate of heating the coal during carbonization.
3. The maximum temperature to which carbonization is carried.
4. The speed and method of removal of the volatile products from the retort during carbonization.

Coals rich in volatile matter yield comparatively large quantities of tar. Rapid heating of the charge during carbonization tends to reduce the quantity of tar and to form tars rich in free carbon and aromatic compounds. Gradual raising of the temperature of the retort or oven results in greater yields of tar, with lower free carbon content and a higher proportion of aliphatic hydrocarbons.

A high maximum temperature insures complete removal of volatile matter from the coke and raises the proportion of free carbon and aromatic compounds in the tar. Rapid removal of the volatile matter from the retort insures high yield of tars comparatively free from free carbon and rich in aliphatic bodies.

From the Diesel engine user's point of view we require large yields of tar rich in aliphatic bodies and low in free carbon content.

In addition to gas works and coke-oven tars, certain tars from low-temperature carbonizing plants have been examined with a view to their use on Diesel engines. These tars have been obtained by the carbonization of coal at low temperatures in plants provided with special arrangements to insure the rapid removal of the volatile products. The free carbon content of such tars is very small, and the hydrocarbons, of which the bulk of the tar consists, are mainly aliphatic.

The removal of water from the tar presents a serious difficulty, as the water is emulsified and cannot be separated by the usual method of warming the mixture and allowing it to settle.

The above-mentioned tars are all derived from coal, but tars from other sources, particularly lignite tars, must not be overlooked.

Lignite tar, according to authorities, can be satisfactorily burned in Diesel engines without ignition gears or any other special modifications. It behaves in the engine similarly to petroleum and shale oils.

By the carbonization of peat a mobile tar of the aliphatic type is obtained. This might prove a suitable fuel for heavy oil engines, but at present the carbonization of peat is not being carried out on a sufficiently large scale to allow of the use of the liquid products for fuel purposes.

It is common practice in normal times for gas works in this country to manufacture a portion of the lighting gas by "cracking" a heavy petroleum distillate and mixing the resulting oil gas with water gas. During this process oil gas tar, also known as "carburetted water gas tar," is produced.

This tar is not a coal tar, but originates from petroleum. It is frequently mixed with water in the form of emulsion, and the greatest difficulty is then experienced in effecting its separation. Though a product of petroleum, oil gas tar consists mainly of aromatic hydrocarbons, the larger portion of the original hydrocarbons having undergone complete transformation during the cracking process.

When free from water and ash, oil gas tar behaves in a Diesel engine in a very similar manner to tar oil, but does not cause pulverizer chocking. The ash content of oil gas tar is very variable, and when attempting to run on this fuel analyses of each batch for water and ash content must be made before accepting delivery.

With engines of over 100 hp. the full-load consumption for raw tars is approximately 0.55 lb. per brake horsepower-hour. Certain allowances would have to be made when engines are to run on raw tars. It is to be noted that:—

1. The maximum mean effective pressure on the engine will be slightly lower than the normal.
2. The speed of engines running over 200 r.p.m. would probably have to be reduced, with corresponding reduction in load.
3. The attendants would have to be more skilled than is normally necessary.
4. The wear and tear on working parts of engine would be slightly in excess of the normal.

In spite of these disadvantages there should be a marked economy due to the great difference in fuel costs.

A specification to ensure a suitable quality of tar for use in Diesel engines would have to be drawn up on the following lines:—

1. The tar must possess a specific gravity below 1.12.
2. The tar must not contain more than 0.08 per cent of ash.
3. The tar must not contain more than 2 per cent of water.
4. The tar must yield at least 9100 calories gross heat value (16,380 B.t.u.).
5. The tar must not contain more than 6 per cent of free carbon (insoluble in mixture of toluol and glacial acetic acid).
6. The tar must not yield more than 10 per cent coke value.

Clauses 1 and 6 would ensure the tars not containing excessive amounts of pitchy substances. The water, ash and free carbon limits are fairly stringent, and would prevent certain tars from satisfying the specification; they are, however, necessary.—Engineering.

When the next artist "sculps" his next symbolic figure of Labor, he might well take into consideration Mrs. Bridget McHugh of Wigan, England. Mrs. McHugh died recently at the age of 80 after 50 yr. as expert "pitbrow" in the Pemberton coal fields. She filled mine cars with a shovel and she worked in all weathers from 6 a. m. to 6 p. m. She died a grandmother with two sons employed in the colliery. Yes, the artist might mold a symbolic Mrs. McHugh with a symbolic coal shovel up against a symbolic coal bank. If you come down to real, actual bona-fide labor, she had the right to talk about it.—The Nation's Business.

In the estimation of authorities, 30 per cent of leather furnishing animals of Italy were slaughtered for food during the war.

Review of Issue of Oct. 1, 1919

On page 884, issue of Oct. 1, 1919, I. H. shows a pinion puller, which appears to be a good arrangement. He furnished no dimensions. What is termed a test clamp for safety valves can be made exactly as this pinion puller. By removing the stem cap, the hooks can be placed under the flange at top of valve body, and the set screw run down on the top of the safety valve stem; in this manner the safety valve spring is relieved of the load.

The A. S. M. E. Boiler Code recommends the use of clamps on the safety valve, when hydrostatic tests are being made, as the springs should not be subjected to the excess pressure used when testing boilers with water pressure.

Water Hammer

On page 885 L. T. B. inquires how to overcome water hammer in large size pipes. The shortest answer that could be given would be—prevent the accumulation of water.

As he gives no details, it may be possible that the large lines cannot be readily changed, therefore ample drainage should be applied at all low points where water of condensation may accumulate.

When a long steam line is permitted to sag at points throughout its length, these low parts if not drained begin to collect the water of condensation, and it continues to accumulate until it rises to such a height that the steam flow is restricted, then the steam begins to force the water on its surface and finally gets the entire body of water under way, the water is then forced together in one body, or slug as it is usually termed, and with the full steam pressure behind it, it goes through the steam line like a cannon ball, and if there are short bends, you will hear the noise that is termed "water hammer," and if the pipes and fittings are not of sufficient strength to resist the ramming and pounding of the water, failure occurs.

Many lives have been sacrificed and much property destroyed by water in steam lines.

Hammering Check Valves

L. T. B. asks how to prevent the hammering of check valves in feed lines.

If the check valve is in good order it should not pound, unless a single-acting pump were being used, which is not likely.

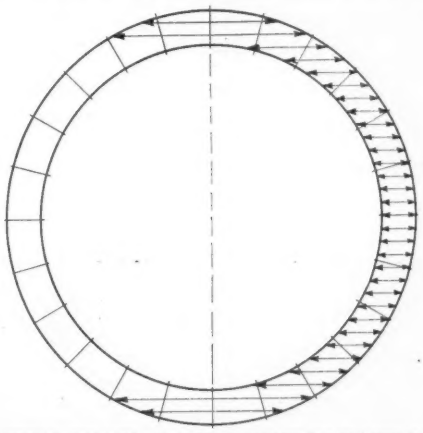
An injector or duplex pump when functioning properly should keep a constant flow of water in the feed line and by so doing the check valve is kept up and not permitted to seat.

It is lifting and seating of the check valve, or rather the check valve striking the top, when lifting, and the seat when closing, that is termed hammering.

The feed pump should be examined for the trouble, one side probably does not start its stroke before the other has finished, and the reduction of pressure in the line allows the check to seat, and when the pressure increases again, the valve lifts.

Examination Questions

On page 887 W. N. L. has some interesting questions. His answer to No. 6 does not appear clear to me. The question is, how do you find the bursting strain on outer shell firebox of Manning boiler? The answer given is, Distance between two sheets times boiler pressure. By this method if the distance between the two sheets (the



SHOWING STRAIN ON OUTER SHEET OF WATER LEG

furnace sheet and shell plate) were 4 in. and the steam pressure 100 lb., the strain per square inch would be $4 \times 100 = 400$ lb. per sq. in.

The strain on the outer sheet of a water leg, it seems to me, would be as shown in the sketch. Regardless of the diameter of the furnaces, the pressure tending to tear the outer sheet longitudinally, is as shown in his answer to question 1, i. e., radius times pressure per square inch.

Considering the water leg of the boiler as the shell or barrel usually is, by having an imaginary line through the center, the steam will act, as shown by the arrows, against all parts of the shell plate throughout its entire diameter, the load being the same as if there were no furnace in the boiler. It is understood, of course, that the staybolts are of some value; but the steam pressure load on the outer shell plate is the same per square inch if the water space be 4 in. or 10 in.

By changing the diameter of the furnace, the collaps-

ing pressure of the furnace plate is changed in proportion; but this change would not affect the outer or shell plate.

QUESTION No. 13

WHAT IS a lap crack, what causes it, and how is it repaired?

The answer as given by W. N. L., it seems, would apply to what is known as fire cracks, as they develop at the girth seam of horizontal return tubular boilers and in the flanges of door and tube sheets of locomotive, or fire box boilers.

It is my opinion that the question referred to cracks which develop along the lap of the longitudinal seams of lap riveted boilers.

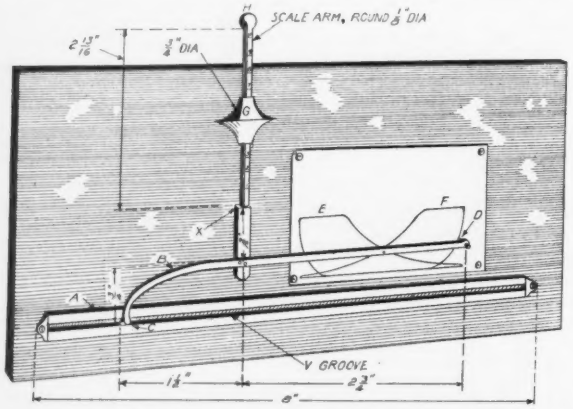
The causes are given as follows: The plates are not in the form of a true circle where they lap each other—the breathing action or expansion and contraction of the boiler—the drift pin.

The state of Massachusetts or any other state having steam boiler regulations does not permit the use of a steam boiler, for generating steam, after a crack is discovered along the longitudinal lap seam.

These cracks have been the cause of disastrous boiler explosions. They were found to develop more readily in a type of return tubular boiler known as the single sheet bottom boiler. This design of boiler is discouraged today, and prohibited to a great extent by many of the prevailing state rules. I. B. LEAVIT.

An Easily Made Planimeter

SOME of the engineers who are fortunate enough to have an indicator, do not possess a planimeter. The working of such an instrument is, however, a comparatively easy job, as will be seen from the illustrations herewith of a planimeter which I have made.



GENERAL ARRANGEMENT OF PLANIMETER

The guide, A, is a strip of iron 8 in. long having a V-groove in the center from end to end. The tracer arm, B, should be made of a light piece of iron or brass to the dimensions shown. One end should be rounded as at C, while at the other a tracer, D, should be provided. The scale arm, H, is ⅛ in. in diameter and round in section, except at one end which is flat, and riveted to the tracer arm. The roller, G, is turned to a knife edge ¾ in. in diameter, and is made an easy fit on H.

To graduate the scale arm, draw accurately a 1-in. square, and starting with G against the shoulder and the tracer at the upper left-hand corner of the square, trace around the square in a clockwise direction to the starting point. This last operation should be repeated twice to secure a good average. At the point on the scale arm, where the roller, G, stops, a mark should be made, and numbered, 1. Nos. 2, 3, etc., should then be laid off equal in length to 1.

The best arrangement is to fasten guide, A, to a piece of soft wood to which the indicator card can be thumb-tacked for measuring. In scaling a card with this planimeter, start at the upper left-hand corner, with G against the collar, X, and trace in a clockwise direction. A. C. WALDRON.

Industrial Training

I HAVE NOTICED with interest the article on industrial training in the Sept. 15 issue of Power Plant Engineering. The logic displayed is splendid and offers food for much thought. Of course, it is a poor rule that won't work both ways, and it is rather strange that the United States Government will spend vast amounts of money to assist in the educating of a few of chosen professions and practically nothing to the masses; this is rather sad.

Let us go to the heart of the trouble and see what we find. It is simply a failure of our Government to compel each state to make and enforce educational laws. A few states have such laws; but, as a matter of fact, the educational interests of this nation are not progressive, enthusiastic and enforcive enough. If we can succeed in improving our general educational system, we will acquire not only a better but a more forceful and productive race and the productive resources developed from their educated minds will make us much more powerful than we are today.

As a matter of fact, we find in many of our manufacturing institutions from two to four men in executive positions directing possibly several hundred men, and out of that vast number we find some that cannot read or write, a few that will average the second grade of a public school, and possibly 10 of the remainder that acquired an education up to the fourth grade.

If you will question a man of from 25 to 40 yr. of age, holding an ordinary job, the first thing he will tell you is that his parents wanted him to go to school, but that he wouldn't study. They then put him to work, and consequently he is now an old man, and doing the same work and drawing nearly the same salary as when a boy, or, he will tell you that "maw" and "paw" said he would have to do as they did, since their parents decided that to read and write was all that was necessary, and as they were raised that way that is the way they intended to raise their children. A man in talking to me along these lines said if a parent could not put his child to work and draw his salary while he was young it would not pay to have children, because it would cost a poor man more money than he would have with which to raise them, a very deplorable situation indeed.

To improve production, prosperity and happiness, in a national way the one step which is necessary to unlock the key which chains the masses of our people is to increase and enforce educational laws. Every child

from the ages of 8 to 18 yr. should be compelled to attend school and receive an ordinary education, and from thereon should be allowed to choose a vocation which he may desire, and when he launches out as an independent bread winner he is then fortified with enough general education to make any branch he attempts easier to master, if it is nothing more than rolling a wheelbarrow of coal. The trained mind can accomplish the task more easily than the one untrained.

I admit it to be a fact for the welfare of all institutions, manufacturing or otherwise, to make them successful, that the employes in the various departments should be trained for their various duties; but if you will observe, where diplomatic and farsighted brains are at the head of an institution combined with a complete knowledge of the various branches of the business, the way this feature of training assistants is accomplished is by adding understudies and as a man is raised to a better position, resigns or is discharged, there is another already experienced and trained to take up his work, and to carry it forward with no more annoyance than the filling of the vacancy of an understudy.

Of course, understudies and assistants should not be maintained as a dead expense, because that is not good management; but the work should be so arranged that the understudy or assistant can at all times do a part of it, allowing him a chance to learn thoroughly the entire work, and by this method enterprises will continuously move onward and upward, gathering talented force combined with greater output.

It is poor policy to educate technically a set of workmen and then turn them loose in a work shop and expect them to accomplish what practically trained help will do, for it is an impossibility; but if you will provide the understudy with a certain amount of technical training and allow the three courses to mold themselves gradually into one, the results will be surprising.

H. W. Rose.

Did the Engine Run Too Fast?

In the Nov. 1 issue of Power Plant Engineering, in regard to flywheel wreck, H. W. Rose makes the statement that the wheel was over-size, and the engine ran too fast. It was a 16 by 42-in., 90 r.p.m., with a wheel 14 ft. in diameter a nd 26-in. face. He says that that size engine should run only 78 r.p.m. and have a 12-ft. diameter wheel with a 23-in. face.

Why should the engine be limited to 78 r.p.m.? Why not only 70 or some other number? And if the engine is strong and powerful enough to handle a 14-ft. wheel, why not? What governs the engine speed? What governs the flywheel diameter? The piston speed of the engine at 90 is not excessive, being 630 ft. per minute and the rim speed of the flywheel at 90 r.p.m. is only 3960 ft. per min. This is quite a way below the safety limit. If the wheel is properly designed, it is good for 5000 ft. per min.; some authorities give more.

I know of Corliss engines 30-in. stroke making 150 r.p.m. and one engine, originally an 18-in. bore, but which has been rebored until it is now 18½ in. in diameter, by 48-in. stroke, which is making 108 r.p.m. and rather heavily loaded at that. Whatever the cause of the engine wreck, I would not hold the speed at which it was operated against it; and I would not pin my faith too closely to catalogs, as I have been looking up a 16 by 42-in. engine, in a certain catalog, and Mr. Rose's figures approach closely the data given there.

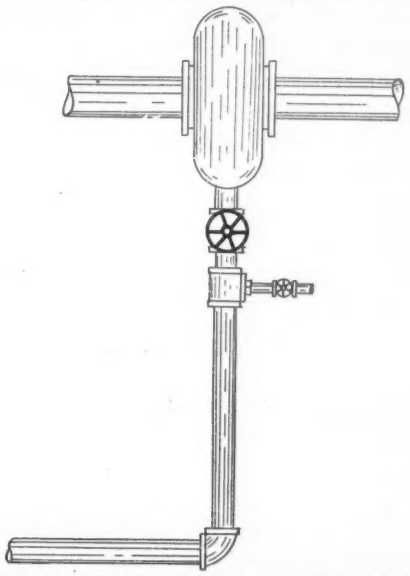
It is the policy nowadays to get out of an engine all that there is in it, and as long as the moving parts will stand it, bring on the load. I would not, however, desire to go much above a 5000-ft. rim speed of a flywheel, nor would I want to run so fast I could not lubricate the cylinder properly.

Tom Jones.

Blowing Out Grease Extractor Drain Pipes

In connection with the use of grease extractors in exhaust lines, especially where heavy oils or grease are used, it will be found that the drain lines from the separators need cleaning out frequently because of the accumulation of oily waste. Usually it is customary to install crosses and tees in the line, plugged, so that the line can be cleaned with wire scrapers or rods.

This is usually a messy job, however, and in one plant



LIVE STEAM CONNECTION FOR CLEANING DRAIN PIPE

with which the writer is connected, we installed a steam blowing arrangement as illustrated. Just below the drain valve on the separator we installed a tee into the open side of which we ran a ¾-in. live steam connection with valve. Whenever the drain line needed cleaning, we closed the drain valve on the separator, held open the low pressure trap or opened the bypass, and then admitted the live steam, which quickly purged the pipe line of any oily accumulation. This proved to be a quick way of attending to this otherwise dirty and undesirable job.

M. A. Saller.

Utilizing Exhaust Steam

In the interesting article by W. R. Davenport, on page 918 of the Oct. 15 issue of Power Plant Engineering, showing what a small percentage of the total steam generated in a power plant can be used to heat feed water, he recommends changing some of the auxiliaries from steam drive to mechanical or motor drive to reduce the amount of exhaust steam wasted.

In most cases that would probably be the easiest and most effective way to cut down the loss due to waste exhaust; but in case that method should not be practicable, the three following expedients are suggested for the same purpose, being applicable to condensing plants only.

First: If it is a turbine plant much, if not all, of the exhaust can be used in the low-pressure stages of the turbines.

Second: An ejector type air pump might be used as some makes of these ejectors are made to run by exhaust steam.

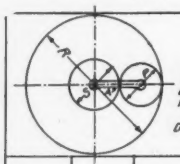
Third: If the condensing apparatus is of ample capacity some of the auxiliaries might be run condensing. While this would not really use the exhaust, it would cut down the steam consumption of the auxiliaries and thus make a saving.

While on the subject of exhaust steam, I would like to hear from some of the readers of this magazine about what percentage of the total steam generated is used to drive the auxiliaries in average modern power plants, condensing and noncondensing. W. B. ROBINS.

Ball and Roller Bearing Discussion

I STILL CONTEND Mr. Trautschold is wrong in regard to the slip he speaks of in ball and roller bearings, and will now endeavor to prove my contention.

RELATIVE MOTION OF SIMPLE EPICYCLIC GEARING


S= SUN PINION;
P= PLANET PINION;
R= INTERNAL GEAR;
A= ARM CARRYING P.
TABLE GIVES THE RELATIVE SPEEDS OF EACH ELEMENT FOR ONE REVOLUTION OF DRIVING MEMBER.
LETTERS, IN FORMULAS, DENOTE PITCH DIAMETER OR NUMBER OF TEETH

STATIONARY MEMBER	DRIVING MEMBER	DRIVEN MEMBER	REVOLUTIONS OF S	REVOLUTIONS OF A	REVOLUTIONS OF P AROUND ITS OWN CENTER	REVOLUTIONS OF R
A	S	R	1	0	$\frac{S}{P}$	$\frac{S}{R}$
A	R	S	$\frac{R}{S}$	0	$\frac{R}{P}$	1
R	A	S	$\frac{R+S}{S}$	1	$\frac{R}{P}$	0
S	A	R	0	1	$\frac{S}{P}$	$\frac{R+S}{R}$
R	S	A	1	$\frac{S}{R+S}$	$\frac{S}{R+S} \times \frac{R}{P}$	0
S	R	A	0	$\frac{R}{R+S}$	$\frac{R}{R+S} \times \frac{S}{P}$	1
P	A	S AND R	1	1	0	1

First: We wish to get rid of one point and that is slip between the races and the housing or shaft. In fact any ball or roller bearing is either fixed or a wedge drive, that effectively prevents it from slipping in the housing or on the shaft. The bearing would be absolutely worthless if slip were permitted at these points. Therefore we shall consider the races as fixed or solid with the housing or shaft.

In any bearing either the outer race or the inner race is stationary and the other rotating. We will consider the one with the outer race stationary and the inner one rotating. In Fig. 2, if the roller turns on its axis, then line g, and line h, will travel an equal distance in opposite directions. In Fig. 3, the roller rolls on the line h, and the axis travels ahead as the roll does, then the line g, will travel a distance equal to two times that traveled over on line h. Thus in Fig. 2, the throw is equal to the radius of the roll, acting equal on both lines; but in Fig. 3, the throw is equal to the diameter of the roll and acts only on the top line, and thus carries it 2 in. while the roll travels one inch on the bottom line.

Then if it were possible to have a bearing with the two races equal in circumference, the inner race would travel two revolutions while the rolls went once around the outer race; but as we must have one smaller than the other by twice the diameter of the rolls, we will consider the effect on the travel for two separate cases.

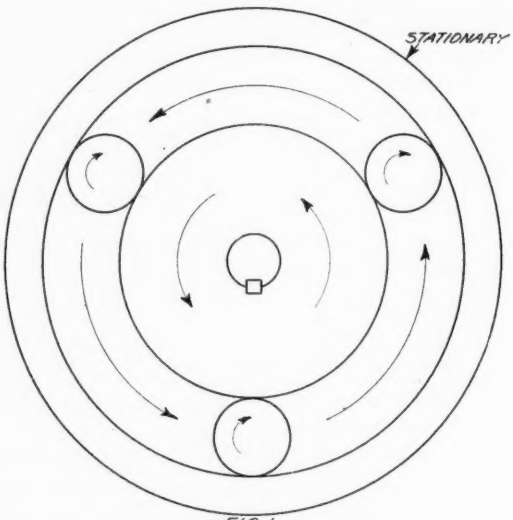


FIG. 1. DIAGRAM OF ROLLER BEARING

FIG. 2. RELATIVE MOTION OF STRAIGHT RACES WITH ROLLER IN STATIONARY POSITION BUT REVOLVING

FIG. 3. RELATIVE MOTION WITH ONE OF STRAIGHT RACES STATIONARY

First take one with outer race 6 in. in diameter and inner race 5 in. in diameter, which would require ½-in. rolls. We find the circumference by multiplying the diameter by 3.1416. Then 6×3.1416 is 18.8496 and 5×3.1416 is 15.7080. Then if the inner race travels we use the formula $\frac{R+S}{S}$ in which R = the internal geared wheel—stationary. S = the inner spur gear—driving. Taken from a table showing planetary gear relations in "Machinery's Hand Book" which is given herewith. We have by substitution $\frac{18.8496 + 15.7080}{15.7080}$

equals 2½ or the revolution traveled by the inner race while the outer race is covered by the rolls once.

Second: Take one with the outer race the same; i. e., 6 in. and the inner race 4 in. in diameter. We would then require 1-in. rolls. Then 6×3.1416 is 18.8496 and 4×3.1416 is 12.5664. Then by substitution in the formula $\frac{R+S}{S}$ we have $\frac{18.8496+12.5664}{12.5664}$ equals 2.5 or the revolutions traveled by the inner race while the rolls travel once around the outer race. Thus we see the smaller the inner race is the greater number of revolutions it must travel to make up for the difference of the circumference of the two races, no slippage being necessary.

In referring to the planetary gears with pinions meshing with concentric gears, I wish to say that if they run on the same principle as the roller bearing, i. e., the outer internal-gear stationary and the spur gear rotating, we find the intermediate gears will travel around the outer gear the same as the rolls in a bearing.

The Ford Motor Car Co. uses the gears thus in its steering gear mechanism on its car. The outer gear being fixed to the steering post and the inner gear fixed to the wheel, the intermediate gears are on a spider which rotates as the gears travel around the outer gear; the axis of the spider connects the steering arm. This is used as a reducing motion, and it is clear that no slippage could be permitted here, and also there could be no reversed motion of the spider and wheel.

In one letter, Mr. Trautschold says it would make no difference whether one race traveled or both; true, as long as they are free, since they will travel at different ratios of speed. Take the figure given in Sept. 1 issue of the gears and consider the outer and inner gears as free and the power as applied to the intermediate gears; then, if the dimensions at the pitch circle are as follows: 6-in. outer gear and 4-in. inner gear and 1-in. intermediate gears, we find if the intermediate gear rotates at 100 r. p. m. the outer gear will rotate 16⅔ r. p. m. in the same direction as the intermediate gear and the inner gear will rotate 25 r. p. m. in the opposite direction. Now, if the outer and inner gears had the same speed as regards number of revolutions, something would have to slip; but we find this is not the case in the action of a bearing.

I hope this explanation will serve to straighten some out on the action of a bearing. True, ball and roller bearings are abused, and I do not want to lead anybody to think they do not need proper lubrication. We find that for heavy duty it is best to use a heavy oil and for light duty, a light oil; but oil there should be, in any case, as there is always rolling friction present.

J. N. Woodruff.

Protecting the Real Engineer with a Real License

Recently there has been quite a lot of discussion of a Federal License for engineers. That there is a crying need for some kind of law that will offer the real engineer some protection against the "Jack Leg Engineer" is not questioned.

It seems that there could be something done that would put a premium on merit, that would state to the public just what kind of an engineer a man is, and at the same time make it obligatory on the employer to pay the man in proportion to his ability.

I was invited to a luncheon, given by a civic organization a short time since. The object of the luncheon was to bring representatives of trades in touch with business men, employers, etc., with a view of each becoming better acquainted with the other. There was the usual line of talk from the business man, but very little from the trades representatives. I feel that labor would do better if it would take more advantage of such opportunities, to make its side of the question plain. There was one laboring man present, however, who attempted to answer the business men, and in as few words as possible I want to give you the gist of the matters that were discussed. Some of the matters discussed, started me to thinking along the line of a possible Federal License law, which, it seems to me, would be a great advantage to all classes of engineers, and at the same time give the employer something for his money, in such a manner that he would have no room to complain.

One business man asked, "Why are engineers not like bookkeepers? A good bookkeeper gets a good salary; a poor one gets a small salary. He does not have a Union to belong to. As soon as it develops that he is a good one there is a place waiting for him. Business is always looking for the accountant that can fill the important place. On the other hand, with your engineers' organization an engineer comes in with his first-class license in his hand. His license is exactly like yours. He belongs to the same union that you belong to. From his credentials, as far as his trade affiliations are concerned there is no difference in this engineer and you. You are both engineers of the same type, class, etc., so far as I can see. Yet this other engineer worked in my plant for years; I thought that I had the best engineer in the city. When he quit I felt that I could never replace him; but I found another with the same license, who belonged to the same union. I offered and employed him for the union scale. In 6 mo. he has saved me more than his salary. I figure that the first man lost thousands of dollars for me. I have voluntarily increased the new man's wages. The thing that I want to know is, how am I to know when I have a good engineer or a bad one, until I have made the costly experiment? How do I know but that another engineer might come along who would save me as much more over the present one? In other words, what is your organization worth to you or me?"

I will admit that I had never looked at the matter in this light. The employer was right in thinking that there was no way for him to distinguish between engineers. The reason that a good bookkeeper and a poor one do not get a good salary alike is plain to me and I think plain to him now. A bookkeeper deals with figures, balances, etc. A man before he becomes successful enough to need a bookkeeper, has to have a working knowledge of these things himself. Therefore he is competent to judge the value of his man and pay him accordingly. In other words, he can appreciate the value of his man.

On the other hand, he does not know the first principle of engineering; and he goes to very little trouble to learn anything about it. Most employers are too busy to give the engineer a little time to explain things.

A big per cent of them look on the engineer as a "Want Column," afraid to talk to him because he is always recommending something new. The bookkeeper recommends some change in the accounting system, and as he understands what the bookkeeper is talking about, he immediately sees the advantage of it and orders it put into effect. The engineer recommends something new, and because he can't understand what he is talking about, he looks on it as a whim of the engineer, or merely something that will lighten the engineer's labor but is of no value to his employer. As a result, the plant is run on from year to year, at an increasing loss.

I do not mean to infer that the employer should have as perfect knowledge of engineering as he has of accounting. That would be impossible, for I can count on my fingers all the employers that I ever knew who had any mechanical talent, and I have only one hand to count fingers on.

As a result of thinking over these questions, the following plan presented itself to me, which I would like to submit for discussion with brother engineers throughout the country. I will welcome any criticism or suggestion that is sent me.

There could be a Federal License Law as follows, that seems to me would offer advantage to engineers as well as to employers.

Let the government select a commission of 10 or 20 of the best power plant engineers of the country. Let these men formulate a set of questions that would cover the field. These questions would be such that if a man answered all of them, he would be a competent man to take charge of any plant of any size. If he answered all of the questions, his federal license would read that he was a 100 per cent engineer of the first class. If he answered 75 per cent of the questions, he would be considered a 75 per cent engineer; if 50 per cent of the questions, a 50 per cent engineer of the first class.

Let this same Commission from the income tax reports arrive at the average wage of the best engineers of the country, which would stand as the minimum wage for a 100 per cent engineer of the first class, recommended by the Commission.

Let the 75 per cent or 80 per cent or 50 per cent man draw this per cent of that amount; more, if the employer felt he was worth it.

The same plan could be applied to the second class ratings of engineers. The plants of the country could be classified as to horsepower. Let the law cover what horsepower the first class or second class men should be allowed to operate. In each division the plants could be classified as 50, 55, 60, and on up to 100 per cent plants. A 75 per cent engineer for a 75 per cent plant, etc., with a 75 per cent salary.

The examiner should be a competent man appointed by the Department of Labor, under civil service. To give the organizations protection and to insure against bribery, graft, etc., there could be an examiner appointed for each federal district. He would be put under heavy bond never to make known the nature of the questions to anybody except those taking the examination, at the time of examination. When there was to be an examination held, he would notify the local trade organization in order that they might appoint five of their highest percentage men to be present during the examination, to see that all was on the square. The organization committee could be different men each time. The applicant should be obligated either morally or financially to keep inviolate the nature of the questions.

A low percentage man would be allowed to present himself for a new examination in 6 mo. If he failed to increase his percentage more than 25 per cent, he would be barred from further examination for one year.

It seems to me that this could be worked out to advantage. There would be a premium on study and increased efficiency. There might be a scarcity of 100 per cent men at first, but there would be more of them in a short time. The good engineer now would have nothing to dread. The low class engineer on a basis of average would still get as much or more than he has been getting. The employer with a 75 per cent or 80 per cent plant would advertise or call for a 75 or 80 per cent engineer, get a 75 or 80 per cent engineer, and pay a 75 or 80 per cent salary. The employer would know what he needed, what it would cost him, and that he was getting what he was paying for. The hard employer, or cheap one would have to come to the standard, while the better class employers would be willing to pay the minimum and generally more for an exceptional man.

If necessary, the examiner could have several districts to look after and hold examinations at stated intervals. There could be a fee of $10 or even $20 for the first examination of the first class, proportionately less for second class, and one-half or one-fourth the first amount for each following examination for higher rating. I have thought over this proposition, and can see nothing but fairness in it, and with a few details added or worked out, I believe that it would put power plant engineering on the high plane where it rightfully belongs.

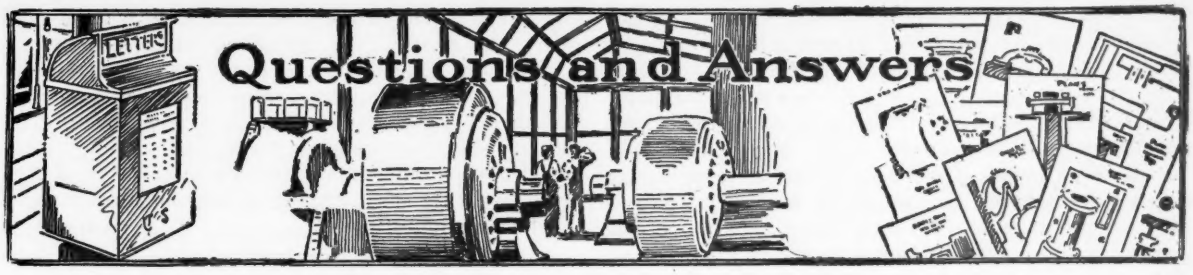
There is no use denying the fact that the real engineer to a certain extent suffers because of the so-called engineer; and there is no use denying that the employer also suffers because of him. It seems to me that this plan, if it can be put through, would solve the question; and anything can be put through that is for the betterment of the people affected in general, if one will only make up his mind to put it through.

I intend starting to work for the passage of such a law unless some of the engineers can show me where it is wrong. It may take time, but there is a way to do it.

H. A. Cranford.

Bad luck in business lies not so much in the stars as in the business man himself, according to business statisticians. Eighty-six per cent of the business failures in the United States in 1918 were classed as due to the individual, while only 14 per cent were assigned to outside causes. Among the factors of the 86 per cent of failures, compilers of figures numbered extravagance, lack of capital and speculation outside regular business. "Lack of character is one of the chief contributing causes to commercial failure," according to J. Harry Tregoe, secretary-treasurer of the National Association of Credit Men. Thrift saving and safe investment not only are proofs of character but developers of character.

According to London Times, the British government has contracted for 100,000 tons of coal monthly from U. S., to be delivered in British ships.



Refrigeration Plant Problems

I HAVE a precooling plant for fruit consisting of four storage rooms totaling 55,000 cu. ft. We operate only during the warm months and an average of 250,000 lb. of pears are put in and a like amount removed daily. The object is to fill all of the rooms, each holding about 250,000 lb. and then empty each room in rotation, filling with fresh fruit at the same time. This gives four days of precooling before shipment.

Indirect air system is used, a 5-ft. fan at 800 r.p.m. circulating the air through the coils in the bunker room to the storage rooms. The fan has its suction in the bunker room and delivers the cold air through ducts. Both cold and hot air ducts are placed in the upper corners of the room and unless care is taken in placing the goods clear to the ceiling, the cold air short-circuits directly across the room without doing any good.

A 24-ton double-acting compressor cares for this storage and the expansion coils total 5760 ft. of 2-in. pipe arranged in four banks each connected top and bottom through a 3-in. header and each tank is fed by a separate expansion valve.

The insulation, which consists of 3-in. cork on 18-in. tile walls, is very poor, losing about 10 B.t.u. per degree difference in temperature per square foot of exposed surface, per day. Room temperature is maintained at from 32 to 35 deg. F.

How is the refrigeration duty calculated and what volumes of air should be circulated per minute for these rooms? What is the allowable difference in temperature of the storage rooms and the bunker room; in other words, what is the correct temperature to carry in the bunker room?

How much liquid ammonia is needed for the expansion side of the system, and could the coils be arranged in any better way? L. W.

ANSWERS

IN THE air-circulating system of refrigeration, heat of the produce to be cooled is carried to the evaporating coils (located in the bunker room) by means of a fan which circulates the heated air from the storage rooms, through the banks of coils where the heat is taken up and the cooled air goes again to the storage rooms.

Short-circuiting of air currents is one of the main points to guard against. This can occur in two places, the most common being in the storage rooms. If the ducts are not properly arranged, the cooled air will pass directly from the cold air ducts to the hot air duct and back to the bunker room without carrying its load of heat. The result of this is noticeable in poor refrigerating effect in the storage rooms and a reduced weight of liquid ammonia being evaporated in the coils. The other place where short-circuiting is liable to occur is in the bunker room. All air passing from the storage rooms to the fan must come in contact with the coils. For this reason, the coil at both ends of the banks must be walled up in such an air-tight manner that air cannot pass by the ends or over or under the coils.

To overcome the short-circuiting in the storage rooms, the cold air ducts must be so arranged that the cold air is discharged down toward the floor. Then when this air takes up heat, it will rise toward the ceiling and pass to the bunker room through the hot air ducts. To obtain the best results, thermometers should be placed in several different parts of the room, and at different heights between the floor and ceiling. Take temperature readings of all the thermometers at the same time as near as possible.

At the bottom end of the cold air duct, fasten a hinged door that will change the current of the air to any point from straight across the ceiling, when wide open, to directly toward the floor when hanging down. An extended cold air duct with branches reaching different parts of the room and those branches provided with a number of small openings for discharge will be found to benefit the produce greatly as a more uniform temperature can be maintained. The object to strive to attain is to break up the air all over the room so that the warm currents rising and the cold currents passing downward will become what may be called well mixed.

If the coils in the bunker room accumulate heavy frost or ice, the installation of a continuous brine spraying system is advisable. Place a pan under the coils and provide a perforated pipe over each coil in the same manner as the water distributing pipe over an atmospheric type ammonia condenser. Mix a strong brine solution, and use a small centrifugal pump to take the brine out of the pan and discharge it over the coils. The operation is continuous and salt must be added at times to keep the solution from freezing on the coils in a thin coating of ice. Keep the density of the brine up to 70 as shown on the salinometer. This brine spraying greatly increases the efficiency of the entire system as the heat is more readily taken from the air and given to the ammonia being evaporated in the coils.

Short-circuiting of the air in either the storage rooms or the bunker room will result in a lower back pressure being carried than is proper for efficient operation.

With an air circulating system where the storage rooms are held at a temperature not lower than 34 deg. F., a back pressure of at least 25 lb. should be maintained. This pressure corresponds with an ammonia temperature of about 12 deg. F. Under such operating

conditions, the best results are obtained with a bunker room temperature of between 20 and 25 deg.

Each bank of coils contains 1440 lineal feet of 2-in. pipe. This amount of pipe will make two continuous coils of proper length to suit the conditions in your plant.

As the banks are now connected, there is a liability of all the ammonia from one expansion valve to the suction line through one coil of the bank. If this does happen, the ammonia will only travel 360 ft. and the expansion valve must be kept very nearly closed or all the ammonia will not be evaporated in the coil. This short travel of the ammonia will result in a very low back pressure or in the freezing back hard on the compressor.

During the overhauling this winter, the coils should be blown out with steam and air to be sure they are clean. Then instead of connecting up as before, make each bank into two coils. Feed the ammonia in at the bottom of one coil and from the top of that coil connect to the bottom of the next. Connect the top of the second coil to the suction line. This manner of connecting will allow the ammonia to travel upward in all the coils and will insure the evaporation of all the ammonia possible and the carrying of the necessary higher back pressure with no danger of freezing back.

The insulation of 3 in. of cork board should not be blamed too much. Look carefully for cracks and poor joints where leakage is liable to occur and plaster tight with a cement that will be furnished by the manufacturers of the cork board. Rooms that are intended to be held at as high a temperature as 34 deg. F. are seldom provided with better insulation than 3 in. of cork board. If the heat leakage were near 10 B.t.u. per square feet for each degree temperature difference, the 24-ton machine would be fairly well loaded taking care of the heat leaking through the walls.

The refrigerating duty is calculated on the total number of heat units taken up by the ammonia in 24 hr. The first heat units considered are those that leak into the storage rooms from the outside. To obtain this figure: First, find the total square feet of surface in the walls, floors and ceiling. Multiply this by the number of B.t.u. that leak through 1 sq. ft. per 24 hr. for every degree temperature difference between the inside and outside of the room. This heat leakage is usually from 2½ to 3½ B.t.u. for well constructed walls as found in the average storage rooms using cork board insulation. Next multiply by the difference between the temperature of the inside of the room and the average outside temperature. Divide this product by 287,000 and the result will be the tons refrigerating capacity required to maintain the room at the given temperature. The other heat units to be removed are those contained in the goods put in storage. Allow 1 B.t.u. for every degree that every pound must be lowered in temperature; that is, multiply the number of pounds of goods by the difference in temperature of the goods coming into storage and that of the room. This total number of heat units divided by 287,000 gives the refrigerating capacity necessary to lower the temperature of the produce.

The sum of the two capacities found will be the total tons capacity per 24 hr. required to care for the produce and heat leakage.

It is considered good practice to add 20 per cent to this figure to take care of heat admitted through opened doors, also given off by lights and workmen.

The 5-ft. fan at 800 r.p.m. will move about 50,000 cu. ft. of air per minute unless more than the usual amount of friction is met with in the air ducts. This velocity should give the very best results.

The evaporating side of the system (5760 ft. of 2-in. pipe) will take about 2000 lb. of ammonia to contain a good operating charge. A. G. Solomon.

Heating a Building by Electricity

If the correspondent who presents his problem in the issue of Nov. 1 had given more information, the answer to his question might have been correct. On account of necessary assumptions the answer is given by example based on the building plan shown herewith. He will therefore have to follow the method of computation here given and then refigure his job to suit the actual conditions.

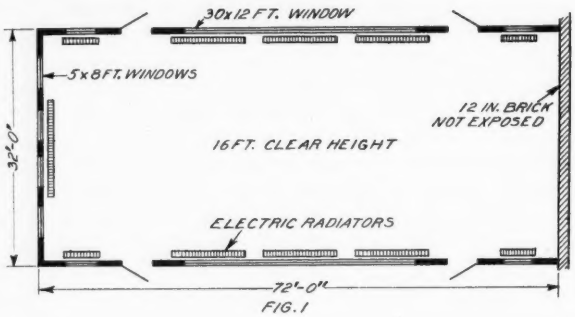


FIG. 1

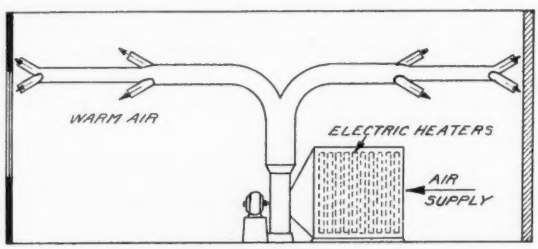


FIG. 2

FIG. 1. PLAN OF BUILDING ON WHICH COMPUTATIONS ARE BASED

FIG. 2. LAYOUT OF INDIRECT ELECTRIC HEATING SYSTEM

Ordinarily, electricity as a medium for heating buildings is out of the question on account of price, but it has advantages such as ease of control and absolute cleanliness. In this case, however, the cost is not a drawback because there is a surplus of 100 kw. in the plant which is apparently available at practically no additional cost.

There are two systems of electric heating that may be employed, the direct and the indirect.

In the direct system, electric radiators are located in the space to be heated, in the same manner as radiators for steam heating, as shown in Fig. 1. The electric air heaters or radiators used are either of the luminous or non-luminous type, that are made in a variety of patterns and in several sizes to meet different conditions. These are usually rated on a wattage basis.

The indirect system employs a fan and pipe distributing system in connection with a central heating unit.

This unit can be made up of a sufficient number of cast grid resistances to warm the necessary amount of air required for heating and also for ventilation if required. The piping or duct work for the distribution of the warm air in the space to be heated is the same as in any other mechanical heating arrangement, as indicated in Fig. 2.

No matter which form of heating is decided on, the requirements must be computed to determine the number, size or capacity of the electric air heaters. For this purpose, the dimensions and layout of the frame build-

GLASS = (30×12)×2 = 720
+(5×8)×8 = 320
1040 SQ. FT. × 1 / B.T.U. = 1144

GROSS WALL = (74+32+74)×16 = 2880 SQ FT.
LESS GLASS 1040
NET EXPOSED WALL AREA = 1840 SQ. FT. × 0.4 B.T.U. = 736

ROOF AREA = 74×32 = 2368 SQ. FT. × 0.3 B.T.U. = 710

CUBIC CONTENTS = 74×32×16 = 37888 CU. FT × 0.01 B.T.U. = 379
2969
TEMPERATURE DIFFERENCE OF 70 DEG. ×70
TOTAL HEAT LOSS = 207,830 B.T.U. PER HR.

FIG. 3. COMPUTATION OF HEAT LOSS IN A BUILDING

ing, as shown in the plan, Fig. 1, will be used. The heat losses through the exposed walls, glass surface and roof must be considered. Then an allowance must be made for rapid warming up at the start and also for air leakage and direction of exposure. For this purpose, the last items may be combined into the equivalent of three-fourths of an air change per hour.

The heat losses will be computed for maximum conditions which are represented by the maintenance of 70 deg. in the building when it is zero weather out of doors. This temperature range is in line with the figures

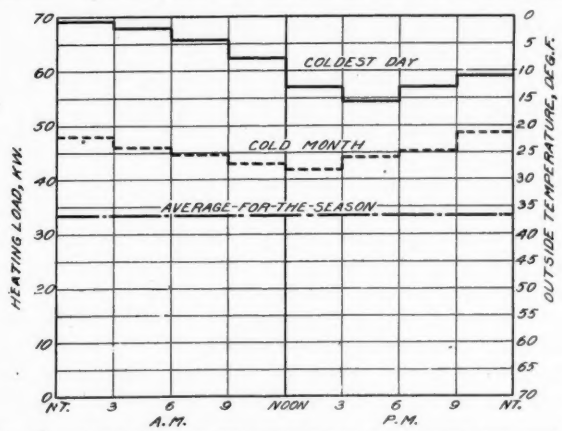


FIG. 4. VARIATION OF HEATING LOAD WITH OUTDOOR TEMPERATURE

given by the correspondent, as borne out by numerous records of weather variations.

From experiment and engineering research, it has been found that the frame walls and doors will lose about 0.4 B.t.u. per hr. per square foot of exposed surface for each degree temperature difference. On the same basis, a tar and gravel roof on boards will lose 0.3 B.t.u., glass about 1.1 B.t.u. and the air leakage 0.01 B.t.u. per cu. ft.

In making the computations, only those surfaces exposed to the weather are taken into consideration. This means the two side walls and their windows, the end wall and its window, as well as the roof.

As shown in Fig. 3, the total glass area is 1040 sq. ft. The gross wall area is 2880 sq. ft., and, deducting the window space leaves 1840 sq. ft. of frame wall that is exposed to the outside. Then comes the roof area of 2368 sq. ft. and the cubical contents, for air change, of 37,888 cu. ft. Multiplying by the constants given and by 70 for the temperature difference gives a total heat loss of 207,830 B.t.u. per hr. which the electric heaters must provide to heat the building properly in coldest weather.

Converting this heat into equivalent electrical energy on the basis of 3415 B.t.u. per hr. to 1 kw., gives a requirement of about 70 kw. of connected load.

Based on average weather conditions corresponding to the extremes noted, a relation may be established as in Fig. 4. This shows how the electric heating load will vary with the changes in outdoor temperature when the building is kept heated to 70 deg. all through the day. The top curve represents the coldest day that may occur, while the middle curve shows the probable load during a cold month of the winter. Taking seven months as the duration of the heating season shows that the average demand for heating will be in the neighborhood of 33 kw.

M. WILLIAM EHRLICH.

Determining Motor Temperatures

I SHOULD be pleased to know the accepted method for taking the temperature of a 50-hp. 2200-v. three-phase 60-cycle slip-ring motor when such a machine is guaranteed to operate at full load at a certain temperature—40 deg. C.

J. S.

A. The temperature of a three-phase slip-ring motor may be taken by the use of a mercury alcohol, a resistance or a thermo-couple thermometer.

The thermometer is to be placed on the hottest part of the machine. If this is bare iron no correction is to be made, but if the bare conductor 5 deg. C. is to be added, or in the case of winding 15 deg. C.

Where the insulation on the windings is cotton, silk or paper untreated to withstand high temperatures, the maximum temperature allowable is 95 deg. C. Where the same materials have been treated to increase their temperature limit, including also enameled wire, the maximum temperature may be 105 deg. C. and wire with mica, asbestos and other high-temperature resistance 125 deg. is considered the maximum.

Caring for Idle Boiler

WE HAVE a 20-hp. vertical boiler, which stands idle 4 or 5 mo. of each half year.

Should it be filled with water or emptied while idle?

W. C. H.

A. A boiler which is out of commission for a greater length of time than 3 mo. should be thoroughly cleaned both inside and outside, thoroughly dried and a pan of quicklime placed in each drum. Boiler should then be closed up, the grate bars covered, and the quicklime placed on the grate bars as well. Precaution should be taken so that no steam or water can get into the internal portion of the boiler.

ANNOUNCEMENT has been made in Alton, Ill., that Empire Gas and Fuel Oil Co. has closed a deal for purchase of 1387 acres of land just outside of Wood River, Ill., for erection of a $25,000,000 oil refinery.

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Coal

It is difficult and even unjust for one not intimately acquainted with conditions as they have up to the present existed to pass judgment on the justification of the demands of the bituminous coal miners or the contentions of the operators. As in the case of all industrial disputes, the questions involved require due consideration and deliberation by proper authority and when arbitrated, the resulting rulings should without further dispute be accepted by all concerned.

With the operation of the majority of the mines of the central competitive district suspended and the country face to face with a coal famine which, unless averted, will not only jeopardize the industries of the country and the comfort and health of the individual but actually imperil our very existence, something must be done, and that immediately. True it is that supplies are still on hand, but to what extent and how long they may meet with our requirements is impossible accurately to determine. It is obvious, however, that these supplies are from day to day and from hour to hour rapidly diminishing and pending the time of resumption of mine operation, war-time curtailments and economies will again have to be put in force. In fact, due to circumstances, unless an agreement is reached between the miners and operators very shortly, even greater restrictions will be forced upon us than during the winter of 1917-18, if not by the hand of the law then by dire necessity.

Before actual suffering is experienced, drastic government action may be expected; but, spite of that, the shortage can no longer be avoided and the problem of conservation will again be encountered, particularly so by engineers, not only collectively but individually. And it is not a question as to what you are going to do about it, but what you are doing about it.

If the former policies of the Fuel Administration are to be followed non-essential industries will be without fuel while others will, as during the war period, have their allotment materially reduced so that again power plant operators will be forced to resort to the strictest form of economy. Not only must there be no waste in the use of the fuel, but in order to reduce this to a minimum and still maintain maximum production all unnecessary energy consumption, whether productive or non-productive, must be avoided. Operators are, however, not without precedent and can, therefore, again exercise the vigilance practiced during the days of hostilities.

During the present emergency, recommendations then made by the United States Fuel Administration may again be followed to advantage:

Weigh and record the fuel used each shift or day.

Heat, measure and regulate flow of feed water.

Provide a correct air supply and a convenient means for the measurement and control of draft.

Keep boiler surfaces clean both inside and out.

Maintain grates in good repair, settings, breechings and access doors free from air leaks and surfaces wasting heat properly insulated.

Utilize exhaust steam wherever possible.

Because of lack of required equipment, many plant operators will not be in a position to follow all of these

recommendations, but wherever it is seen possible to eliminate waste and thereby secure a greater degree of economy no efforts should be spared.

In addition, co-operation of plant personnel may be instrumental in bringing about added economies along the routes of transmission and utilization and along these lines the following suggestions may be amended:

Eliminate operation of motors when machines are idle.

Group machines so that driving motors and engines may operate at highest efficiency.

Oil bearings regularly and inspect them for alinement.

Eliminate belt slippage as far as possible.

Reduce elevator service to a minimum.

Reduce use of hot water to a minimum and stop all leakage of spigots, pipes, etc.

Replace carbon lamps with more efficient units and reduce number of lamps used wherever possible.

Savings are possible in every plant and during the existing emergency, as during the war, the engineer is again called upon to meet the issue. Do your part and remember that the less the waste, the longer will the supply of coal on hand be available.

Review of Issue of Oct. 1, 1919

"Oh, here's the magazine; wonder what's new." That is about the average greeting the latest issue of any magazine gets. Some people read the leading article, some the letters, or editorials, while some read practically the whole number. At least one reader, however, seems to have hit the nail on the head, in his method of using Power Plant Engineering. He evidently studies it, as his letter on page 1077 will show. The first paragraph is an excellent example of the benefit to be obtained by really studying an article. He refers there to the similarity existing between a pinion puller and a test clamp for a safety valve. Simple enough, but how many thought of it?

It is the same all the way through, from the leading article to the last page, not omitting the advertisements. Much more than a mere description of a power plant is contained in the leader; it is usually a good example of modern power plant practice and full of good suggestions for those who study it. This holds good for most of the other articles, steam, gas, electrical, etc. Even the most radical can appreciate a good story, especially when it is true; therefore, the biographical sketches, not so much for what is in them, as for what they suggest. The practical letters contain no end of useful suggestions, as well as the questions and answers, a great many of the questions having been answered by practical operating engineers, who speak from personal experience.

Coming right down to the point, it is not solely the information contained in these articles, which is so valuable, though many of them do present valuable engineering information. It is the method pursued in reading, the method of mining, so to speak, that really decides the amount of good that is secured from them. The real "gold," in this instance, is found in the reader's mind, the tools for mining it in books and magazines. The thing to do is to study the article carefully, and thoroughly, and then see in how many ways the knowledge gained can be applied.

If every reader did this, what would be the result? It would create more interest in what was put into the magazine and as it is the reader who really makes it, the magazine would grow out of all bounds, if not in size, surely in quality.

Measuring Producer Gas

WHILE it is a simple matter to measure the amount of gas supplied to a gas engine from a town's gas supply, it is difficult to measure the quantity of gas used from a producer or from a coke-oven or blast-furnace, owing to the fact that the pressure and temperature of the gas are not accurately determined. Yet, for a complete knowledge of the performance of the engine, a knowledge of the quantity of the gas supplied is necessary. Two methods are, however, available. The first is by means of the Pitot tube. The tube is inserted in the center of a straight line length of the pipe so that the axis of the vent portion of the tube is parallel to the direction of the flow of the gas. The second method is to place a standard orifice between the flanges of two straight lengths of the pipe and to measure the difference of pressure on the two sides, being necessary only to have the proper ratio of orifice diameter to pipe diameter and to have the orifice the proper shape in order to insure accuracy. In both methods, the difference of pressure must be accurately determined; one way of doing this being to lead the two pressures to the opposite sides of a bell float which is water sealed from the atmosphere, the position of the float being directly proportional to the difference of pressure.

ONE OF the greatest statesmen in the United States, whose name cannot be disclosed, recently made the following statement concerning the activities of the Engineering Council:

"Your task is appalling. You have been elected to lead engineers into a political reform. They are the most unresponsive citizens that we have. Your organization has a praiseworthy purpose, but if it were sponsored by almost any other group of reputable men than engineers, there would be more promise of success. If your organization succeeds, I believe you will find that it will not be the engineers who have carried through. Their aloofness and indifference in all matters outside of their own professional sphere are among the unexplainable things in our political life."

The American Association of Engineers is placing this statement before each of its members as an illustration of the opinion which politicians hold concerning the value of engineering organizations as political entities. His statement that their "aloofness and indifference in all matters outside of their own professional sphere are among the unexplainable things in our political life" should act as a spur to every engineer, for no truer statement of this situation could be composed. The individual engineer must be made to realize that his direct co-operation is necessary if the political genesis of the profession is to be accomplished, and it is to this end the statement should be given the widest publicity among engineers.

A New Overfeed Automatic Stoker

ONE of the latest additions to the power plant equipment field is the stoker, shown here. It is of the inclined, moving grate, overfeed type.

In operation, coal is fed at a uniform rate from the hopper, by means of an oscillating, semi-circular feeding block to the coking plates, where distillation of the volatile gases takes place. The coal then passes onto the moving grate surface. This surface is made up of a number of inclined step sections, depending on the width of the stoker, to which an up and down motion is given by means of a number of eccentrics, one to each section. The eccentrics are so arranged that no two of the sections move in a like manner at the same time. The coal, partly by gravity, and partly by the motion of the step sections is caused to move downward toward the ash receptacle, during combustion.

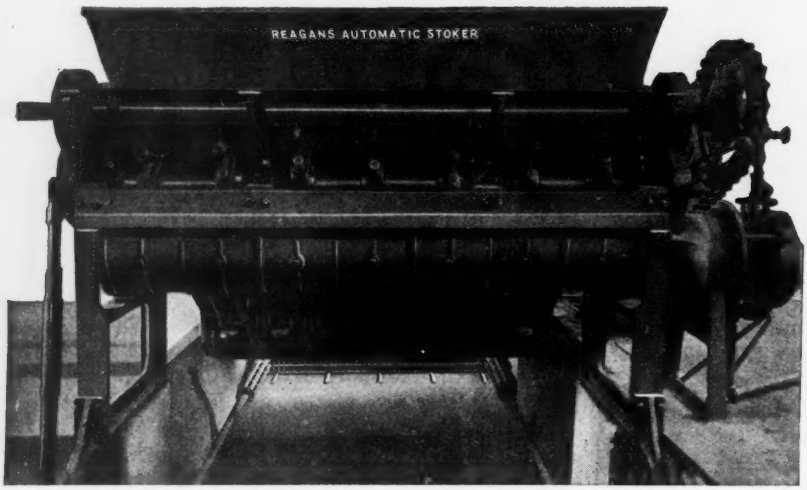


FIG. 1. FRONT VIEW OF STOKER

The reciprocating motion of the step sections results in the production of a loose open fire bed which, the makers claim, enables 60 lb. of coal per sq. ft. per hr. to be burned with less than 1 in. forced draft pressure. The steps are made in small sections so as to be replaced readily when necessary. In the faces of the step plates holes are drilled ½ in. in diameter and 1 in. deep, which serve to collect and retain ashes for the protection of the metal against burning out. Small air holes are drilled between these ash cavities, into the air duct.

Each individual section has its own air duct placed directly beneath it, and communicating with the main blower duct, at the front, through which air is forced by means of a 20-in. fan.

At the back end of the grate surface is the water-cooled extension grate, the purpose of which is so to retard the movement of the coal as to increase the thickness of the fuel bed, as it nears the ash receptacle. When the coal has been consumed, or nearly consumed, it passes from the extension grate into the ash receptacle, which is composed of the water-cooled lower part of the bridge wall in back, and the extension grate in front. Here the ash is allowed to give off some of the remaining heat before it is removed.

In the removal of the ash from the ash receptacle, a rather novel method is employed. The lower part of the bridge wall is eliminated and in its place is a cast-iron "pusher" extending the full width of the stoker, motion of which is derived from a crank on the stoker driving mechanism, operating through a bell crank. When it is desired to remove ashes, a driving pin is inserted to operate the "pusher," which then moves forward from its position under the bridge wall, pushing before it part of the ashes, which pass under the extension grate into a pit, whence they may be removed by any suitable means. The ashes in the ash receptacle at the back of the furnace provide the means for keeping the fire sealed.

It is claimed that the use of the overfeed principle results in the ash being kept in a zone of low temperature, and that this, together with the motion of the step section, reduces to a minimum the tendency to form clinker.

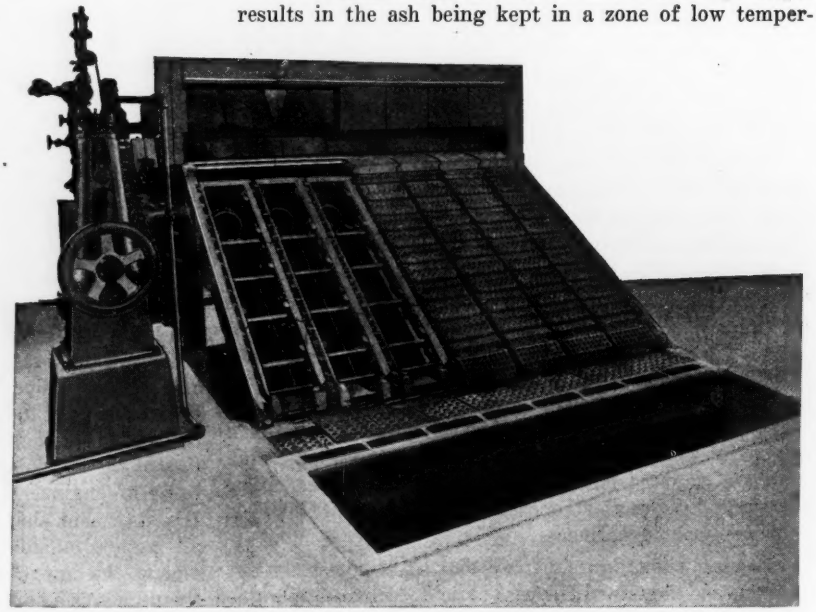
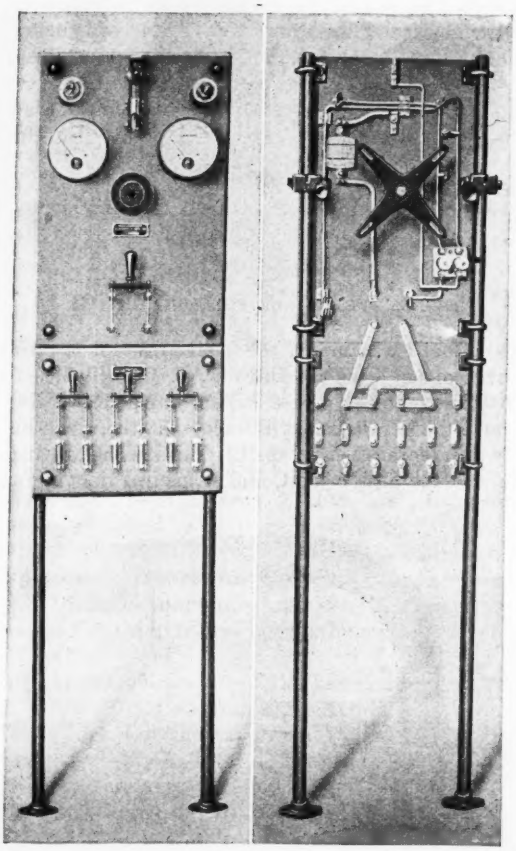


FIG. 2. GRATE SURFACE WITH THREE SECTIONS OF STEP PLATES REMOVED

Ready-to-Wear Switchboard

SWITCHBOARDS, which are particularly adapted for smaller installations, are the ready-to-wear kind. These are suitable for the control of direct-current generator and three lighting circuits.

One feature of this switchboard particularly in its favor, is that it can be placed in operation by simply connecting the leads from the generator and feeder circuits to the terminals provided for that purpose. Contrast this with the expenses entailed in the purchase of meters, switches, circuit-breakers, slate slabs, frame work and the work of designing and assembling the complete panel on the job.



FRONT AND REAR VIEWS, READY-TO-WEAR SWITCHBOARD

The installation of the old types of switchboard involved a great deal of detail work. Each piece of apparatus must be ordered with careful consideration given to the type and capacity. Drilling templets of each must be secured and a considerable sum must be allowed to cover investment in machines and tools for drilling the slate and bending the copper strap connections. Finally, when the panel is built up and installed, it may operate and it may look pretty good, but one cannot be absolutely certain.

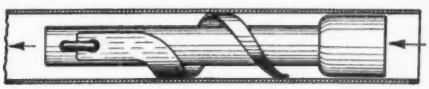
The accompanying illustration is typical of two types of panels, both of which are suitable for 125 and 250-v. installations up to 600 amp. capacity, and permit a choice in number and capacity of feeder circuits.

Condenser Tube Cleaner

CLEANING a condenser is at best a messy and rather tedious task, as anybody who has ever had occasion to clean one will agree. Of course, it depends to some extent on the quality of the water used for condensing purposes, consequently the frequency of the cleaning operation, as well as the facilities at hand with which to do the job. Time is also an important consideration, as it is often necessary to get the condenser back into service with least possible delay.

With these points in view, as well as the necessity of thoroughness in cleaning, the simple condenser tube cleaner illustrated, has been designed. It consists essentially of a piston of the shape shown, to which is fastened a spiral scraper of flat spring steel, so shaped and proportioned as to cause an equal pressure to be exerted throughout its length. In the case of 1-in. tubes, the scraper is made of 0.032-in. spring steel, and it diameter being slightly greater than the inside diameter of the tube, supplies the necessary pressure for the scraping process. The piston is somewhat smaller than the inside diameter of the pipe (0.045-in. for 1-in. tubes) to allow it to pass freely through irregular parts of the tube.

To clean a condenser, a number of these cleaners are forced into the ends of the condenser tubes. Water at a pressure of 100 lb. per sq. in. is then supplied, through a special nozzle fitting snugly into the end of the tube,



SHOWING HOW CONDENSER FITS INTO TUBE

to force the cleaner through the condenser tube. The pressure of the spring scraper on the tube surface retards the motion of the cleaner, which allows water to pass the undersize piston with sufficient velocity to wash out the removed deposit. The cleaners are shot out against the condenser head and fall into the water box, where they are easily gathered. Air should not be used to replace water, but the cleaners may be propelled by means of an iron rod or pipe, if desired.

When the scraper part has been worn out after an estimated life of 500 tubes they can be readily replaced. The manufacturers state that with a suitably arranged platform with the water supply controlled by a foot operated quick-opening valve, three men can clean 3000 tubes per day of 8 to 10 hr. with 100 cleaners.

CAPTAIN A. TARDIEU, in address before Franco-American Section of Cercle Volney on work of reconstruction already accomplished by the French Government, states that of 1400 mi. of railway track destroyed, 1260 have been repaired; of 670 mi. of canal destroyed, 450 are now in working order; of 2160 bridges destroyed, 588 have been rebuilt; of 550,000 houses destroyed, 60,000 have been reconstructed; of 4,500,000 acres laid waste, 1,000,000 have been cleared and made ready for crops.

ARE YOU getting everything possible out of life? The man who does a 100-yd. dash in 10 sec. hasn't much time to study the scenery or the other fellow's methods.

A New Shaking Grate

IN THE installation of a hand-fired boiler, one important consideration is the type of grate to be employed. It should be one having a low upkeep cost, but whether it be of the stationary or shaking type will be decided by individual circumstances. One of the newest designs of the latter type is that illustrated herewith, consisting essentially of a number of comparatively heavy grate bars, operated manually, by means of removable hand levers. The grate is divided into a number of sections, dependent on its size, each with an individual operating lever.

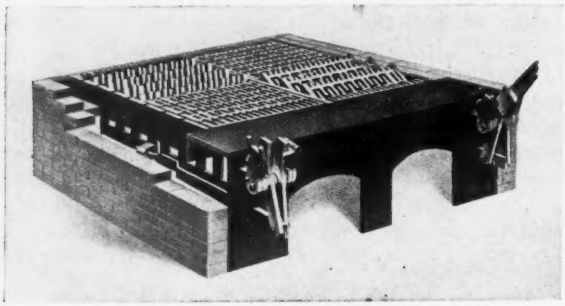


FIG. 1. GENERAL VIEW OF STOKER

The grate bars are of an unusual design, in having the teeth of various lengths, and staggered, so that the teeth of one bar interlock with those of the adjacent bars. When the grate is being shaken, this helps to some extent to break up clinker. The grate is double-acting; that is, the bars oscillate in both forward and reverse directions. The extreme opening between them is not large enough to allow obstructions to hinder the action of the grate. The bars are made with various size openings to accommodate different kinds of coal, the iron used

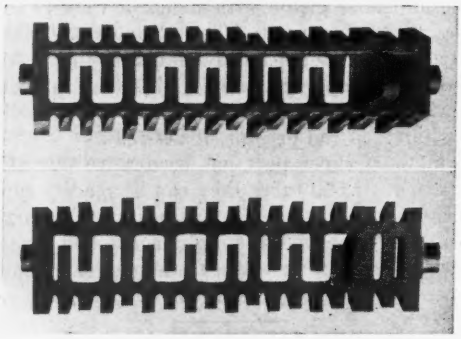


FIG. 2. TOP AND BOTTOM VIEW OF GRATE BAR SHOWING CONSTRUCTION AND LARGE AIR SPACE

being a special mixture of extreme hardness, for which is claimed an unusual degree of heat resistance.

The operating mechanism is simple and rugged and conveniently located at the sides of the fire doors.

DISPATCH to Philadelphia Public Ledger from Barbourville, Ky., states that southern and western Kentucky counties are centers of considerable petroleum activity at present time.

Heater for Fuel Oil

NOW THAT coal is so high in price, particular attention is being given to fuel oil burning, and in this connection it is interesting to note the fuel oil heater shown herewith. This apparatus is designed for the preheating of fuel oil before it is supplied to the burners under the boilers.

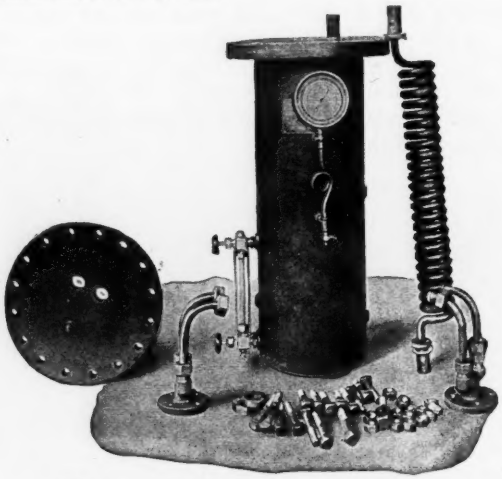


FIG. 1. DETAILS OF FUEL OIL HEATER

In actual operation of the heater, the oil is pumped through coils of seamless drawn steel tubing which form the heating surface. These coils are of helical construction and the arrangement is such that there are no oil joints inside the heater shell. This is the distinctive feature of the heater joint, and it insures that there are

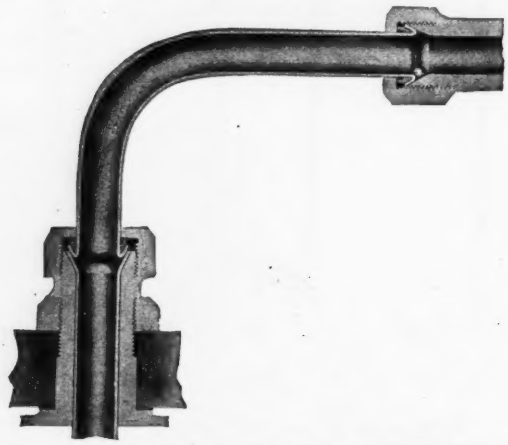


FIG. 2. PATENTED JOINT EMPLOYED IN HEATER SHOWN IN FIG. 1

no leaking oil joints inside the shell, which might cause contamination of the condensation of the high-pressure steam. Figure 1 shows the heater disassembled and this, considered in conjunction with the sectional picture of the joint, gives a clear idea of the construction.

ACCORDING to Wall St. Journal, a number of steel companies are changing from coal to fuel oil, and others are preparing to do so. One steel company in western Pennsylvania alone used 30,000 gal. of fuel oil a day.

Associated Manufacturers of Water Purifying Equipment

BORN almost out of necessity while the recent war was in progress, the Associated Manufacturers of Water Purifying Equipment has now become a permanent organization. Although formed primarily for the purpose of getting the priority committee to enable members of the Association to obtain sufficient supplies for the operation of their plants, there were other reasons for the organization which did not disappear with the close of the war. Consequently, at a meeting held in New York in March, 1919, it was voted to continue the Association.

Besides establishing friendly relations and co-operation among the members, its work will consist largely of standardization—such as standardization of equipment sizes, of guarantees to customers and of terms of sales. Co-operative advertising, educational campaigns, and freight rates are other matters which will be taken up.

It will be an endeavor of the Association to have architects and engineers specify filters in such a manner that all manufacturing companies figuring on the specifications will estimate on filters of the same diameter. This can readily be accomplished by a specification by architects and engineers of what the rate of filtration should be. Benefits from all standardization and co-operation effected by the Association will naturally be realized by ultimate purchasers and users.

Committees were appointed to secure data on the standardization of sizes of pressure filters and to draft standard paragraphs for contract forms. Reports from these committees were favorably received at the meeting, held in Pittsburgh Sept. 9, 1919, and the committees were instructed to continue their work.

Eligibility for membership in the Association is restricted to individuals, firms and corporations regularly engaged in the manufacture and sale of apparatus or equipment for the purification, rectification or sterilization of water.

The present officers are F. B. Leopold, of the Pittsburgh Filter Mfg. Co., chairman; Arthur M. Crane, of the New York Continental Jewel Filtration Co., vice-chairman, and H. G. Tate, of the Borromite Company of America, secretary.

The last meeting of the Associated Manufacturers of Water Purifying Equipment was held in Omaha at the Hotel Fontenelle, Monday, Nov. 17.

Temperature in Diesel Cylinders

IT HAS been estimated that the temperature in the cylinder of the Diesel engine is somewhere in the region of about 3000 deg. F. This temperature does not, of course, depend upon the size of the cylinder, but merely upon the quality of the fuel burned and upon the ratio of air to fuel during combustion. Why, then, the question may be asked, if we can deal with this temperature in a cylinder of 2 ft. diameter, can we not also deal with it in a cylinder, say, of 5 ft. diameter? One reason is that with the larger casting the thicknesses of the various parts are greater and the whole casting is far more complicated in shape, so that the unequal strains due to the hot gases on one side and the jacket water on the other are far more likely to cause fracture. It has been shown, as a result of the investigations of the Gaseous Explosions Committee of the British Association, that the intensity of the heat radiated by the incandescent gases to the walls of the cylinder of an engine, increases with the size of the cylinder; the intensity also increases with the richness of the mixture. Until a suitable material can be found which, while having a strength equal to that possessed by cast iron or steel, as at present used, is also able to withstand the effects of considerably higher temperatures, the size of Diesel cylinders is hardly likely to show any considerable increase.

News Notes

THE DIVISION of Industrial Research of the National Research Council is arranging for the formation of a co-operative association to plan and support fundamental researches in alloys. Although much valuable work has been done in this field by scattered investigators there is no doubt that a well-planned and co-ordinated effort by a co-operative association working under the general guidance of the National Research Council and composed of specialists representing both the manufacturers and the more extensive users of alloys can produce additional results of great importance.

It is planned to create a special scientific staff composed of a Director and Assistant Director of Research and a group of scientific investigators and technical experts who shall give their whole time to the work. To finance the organization, each member of the co-operative association will pay $1000 a year, and all contributing members, who may be either alloy manufacturing or using individuals, firms or companies are to benefit alike by the results of the researches.

THE CROCKER-WHEELER CO., of Ampere, N. J., has just inaugurated a plan of training for its foremen and other factory supervisors which is of considerable interest. A group of 62 men has been formed to pursue a three months' Course in Modern Production Methods, which comprises the study of specially-prepared text units, the solution of problems relating to the units, and the discussion of this material at six biweekly meetings held after hours in the plant. These meetings will provide an opportunity to bring home the application of the work to the special problems of Crocker-Wheeler Co. production. At each meeting, a lecture will be delivered by an experienced production man and the lectures will be followed by a round-table discussion. Included in the group, besides foremen, are the superintendent and three assistant superintendents, which insures that the meetings will be highly resultful to the members of the class. The subjects to be studied are:

How to promote team work in the shop.

Handling men in a way to increase production and promote harmony.

How production should be organized.

Efficient purchasing, scheduling, routing, repairing, etc.

Keeping down the overhead by stricter cost keeping.

Major problems of management.

The course is under the direction of the Business Training Corporation of New York City, which supplies the study material and the class instruction.

U. S. Civil Service Commission announces examinations as follows:

December 9—Engineer of Tests, $8.80 a day; Mechanical Assistant in Refrigeration, $1200 to $1400 a year; Master Machinist, Armor Piercing Projectiles, $12.40 a day; Master Machinist, Guns up to 6-in., $12.40 a day; Master Machinist, Guns Above 6-in., $12.40 a day; Structural Steel Draftsman and Designer, $2400 a year.

December 10, 11—Mineral Geographic Aid and Mineral Geographer, $1200 to $2400 a year.

December 16—Inspector (Mechanical), Inspector (Electrical) and Inspector (Mechanical and Electrical), $5.20 to $8.80 a day; Mechanical Aid, $10 a day; Electrical and Mechanical Engineer, $14 a day.

Apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

Trade News

George W. Heald, formerly Chief Assistant Engineer for the City of Chicago, has taken a position with the Diamond Power Specialty Co., in its Chicago office, 809 Ashland Block.

Fred W. Duemler, formerly with the Uniflow Boiler Co., Philadelphia, is now connected with The Bigelow Co., New Haven, Conn., as their manager of sales in the Philadelphia, Pittsburgh and Chicago Districts.

The Frederick Engineering Co. announces its incorporation for the manufacture and sale of automatic stokers, steam jet ash conveyors, and centrifugal pumps. The works of the company are located at Frederick, Md., the main office at 61 Broadway, New York City.

The M. H. Detrick Co., of Chicago, Ill., has just completed arrangements for representation on the Pacific Coast, with S. Herbert Lanyon, Sales Engineer, 507 New Call Bldg., San Francisco, Cal. The company has also recently arranged with H. A. Paine, 1302 Nance St., Houston, Texas, for representations in Texas.

Russell W. Stovel, who recently returned from France, where, as Lieutenant-Colonel of Engineers, he served as Chief of the Terminal Facilities Division of the Army Transport Service, has been appointed a consulting engineer of Westinghouse, Church, Kerr & Co., Inc., and, as a member of that organization, will devote his entire time to the company's electrical and mechanical work. Mr. Stovel has had an unusually comprehensive experience in the electrical and mechanical problems connected with central power station and steam railroad electrification work, from the fundamental economics involved, to design, construction, equipment and operation, together with a most valuable experience in mechanical handling at docks and terminals.

Charles F. Scribner, formerly industrial engineer with the Colt's Patent Fire Arms Mfg. Co., Hartford, Conn., and more recently consulting engineer for L. V. Estes, Inc., Chicago, has become associated with the Business Service Corporation of America, Chicago, Ill., in the capacity of vice-president and chief engineer.

The Chicago Pneumatic Tool Co. announces the removal of their Cincinnati office from the Mercantile Library Building to the Walsh Building, Pearl and Vine Street, where a service station with a complete stock of pneumatic tools, electric tools, air compressors, oil engines, rock drills and repair parts will be maintained.

Received from The Universal Automatic Under-feed Stoker Co., of Johnstown, Pa., a catalog describing the company's new stoker.

The Schutte & Koerting Co. has lately issued a pamphlet entitled "Our Part in the War."

Catalog No. 3 of Barber-Greene Co., Aurora, Ill., illustrating and describing the company's portable and stationary belt conveyors for loading and unloading cars, piling coal, loading wagons and trucks, and many other uses, has just been received.

The Kennedy Valve Mfg. Co., of Elmira, N. Y., has just published a bulletin entitled "Kennedy Veterans," the "veterans" being a number of this firm's valves which have seen a number of years of service, and are still in use. One particular installation is mentioned as having been installed over 35 yr. ago.

Centrifugal Pump Sales Service Data is the title of a new bulletin issued by the Goulds Manufacturing Co. The information given is of a technical nature, taking the form of a text book on the subject of centrifugal pumps and was first used in serial form as letters to the company's sales organization. The bulletin contains a fund of information on theory, design, testing and use of centrifugal pumps.

Tests to determine the practicability of employing thin-plate orifices in pipe lines, and the conditions most favorable for their use as measuring devices, have been completed by the Engineering Experiment Station of the University of Illinois. The results of these tests are given in detail in Bulletin No. 109 entitled, "The Orifice as a Means of Measuring Flow of Water through a Pipe," copies of which may be had without charge by addressing the Engineering Experiment Station, Urbana, Ill.

The following new literature has been received from the Ingersoll-Rand Co.:

Form No. 8707 is a 40-page, 6 by 9-in. bulletin on "Little David" pneumatic drills, grinders and saws. This catalog illustrates the various sizes and models of the different machines and contains detailed descriptions concerning the particular tool to use for a given purpose. The descriptive matter is supplemented with a number of tables giving air consumption of the various tools, etc.

Form No. 945, entitled 'Tis a Good Investment, is an 8½ by 11-in. form illustrating ER and FR compressors in small machine shops, power houses, garages, etc.

Form No. 954 is descriptive of the air lift method of pumping.

Form No. 9029 is the Ingersoll-Rand Co.'s Pictorial Products Catalog. This is virtually a picture book, illustrating and describing, as it does, practically the entire line of products marketed by this concern.